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PREFACE

The Bhabha Atomic Research Centre is a multi-disciplinary laboratory engaged in Research and Development in the area of nuclear science and its applications. In addition to fundamental and applied research, BARC is involved in development studies aimed at providing all the necessary support to the nuclear power programme which is now based entirely on indigenous technology. BARC is also responsible for the development of technologies for all the steps in the nuclear fuel cycle, starting from ore dressing to the management of nuclear wastes. In addition to research laboratories and major experimental and test facilities, certain production plants needed to support nuclear power programme are also built by BARC. Results of laboratory work carried out at Trombay have been the basis of some of the industrial and semi-industrial scale plants set up at many places in India. Scientific support to regulatory functions connected with nuclear facilities throughout the country, and training of manpower for the entire nuclear programme form significant parts of our activities.

It is difficult to bring out an annual report of the scientific investigations and accomplishments of BARC in a concise manner. In this annual report an attempt has been made to bring out the salient results of our activities during the last year organised under various disciplines. The work mentioned in each of these areas would have been carried out in more than one Division. This is primarily a characteristic of this Centre which brings out the multi-disciplinary nature of its activities. Some of the development studies are oriented to a particular project with specific ends in view.

Detailed results of R&D work are published in technical reports or in scientific journals. The publications listed after each chapter would provide further information to those who need it. In addition to this, each Division of the Centre brings out an annual report giving information in much greater detail about the activities of that particular Division.

For the first time such a consolidated scientific report is being released by BARC. It is hoped this publication will help to disseminate information to the scientific and technical community at large.

P.K. Iyengar
Director

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1. PHYSICAL SCIENCES

1·1 Nuclear Physics

Experimental research in nuclear physics was carried out utilizing the Van de Graaff accelerators at Trombay and the Variable Energy Cyclotron (VEC) at Calcutta. Experimental measurement with alpha particles of energy in the range of 25 to 37 MeV bombarding magnesium-24 targets have yielded new information on the intermediate structure resonances in the compound nucleus silicon-28. Angular correlations of fission fragments in fission of uranium-238 induced by alpha particles of energy from 40 to 60 MeV were measured to determine the distribution of momentum transfers in the events leading to fission. The angular distributions in elastic and inelastic scattering of 50 MeV alpha particles from bismuth-209 were measured and the results were analysed to obtain information on the various optical model parameters. In a study carried out in collaboration with TIFR, it has been shown that, contrary to earlier conjecture, the 2256·3 KeV high spin isomer in rhenium-182 has a three neutron and one proton configuration. The excitation of the giant resonance in the inelastic scattering of 270 MeV helium-3 beam on nickel-58 was investigated in a collaborative experiment with Indiana University Cyclotron Facility, USA.

The angular distributions were measured in ^{6}Li $(\alpha, \alpha d)$ ^{4}He at 45 MeV alpha bombarding energy obtained from VECC to investigate the shrinkage of deuteron cluster in ^{6}Li in relation to fixed α-d scattering. Using the 5·5 MV Van de Graaff accelerator and Lexan detectors, Coulomb subthreshold fission cross-sections of uranium-235 and uranium-238 at proton energies below 4 MeV were measured. Proton induced X-ray emission studies of samples of normal and cancer tissues of laboratory animals are being carried out for possible differences in trace element concentrations.

The installation of the main accelerator tank and the four sulphur hexafluoride gas storage tanks of the Medium Energy Heavy Ion Accelerator (14 UD Pelletron) now being set up at the TIFR as a joint BARC-TIFR project has been completed. The civil work on the construction of a tower around the main accelerator tank and the associated laboratories has reached the final stage. Electrical and airconditioning works are also nearing completion. Work on setting up of the main accelerator column has started. Significant progress has also been made on the fabrication of the experimental facilities for use with this accelerator.

1·2 Condensed Matter Physics

Neutron diffraction studies of the alloy systems, terbium-manganese-iron and iron-manganese-tin, were carried out to understand their magnetic structures. A small angle neutron scattering spectrometer was set up at CIRUS. It was used to study inhomogeneities in beryllium oxide, high carbon steel and aluminium-zinc alloys. In collaborative experiments carried out in Brookhaven and Argonne National Laboratories (USA), phonon dispersion relations and phonon density of states in the geophysically important mineral, forsterite (Mg_2SiO_4), were measured. The results are in excellent agreement with predictions made at Trombay. The first triple axis spectrometer complete with microcomputer control was commissioned at DHRUVA reactor for inelastic neutron studies. A four-circle diffractometer and a profile analysis spectrometer were also installed at the reactor.

Using the 'Compton profile' technique, a new method of determining band occupancies in transition metals was developed and was applied to nickel and manganese. Computer simulation experiments revealed new plausible pathways of reorientation of NH_4^+ ions in ammonium halides and of SO_4^{-2} in $LiKSO_4$. Raman spectroscopic study of antimony showed that the interaction of interband electronic excitations with optic phonons leads to the observed symmetric (Fano) line shape of phonons. The dispersion of the existing laser Raman spectrometer was enhanced by adopting a grating with 2000 lines/mm.

Effect of disorder on superconductivity was investigated by subjecting samples of the compound, $Cu_2Mo_6S_8$, to a high-power laser pulse; the drop in the critical temperature T_c correlates with the estimated shock-pressure. Based on Jahn-Teller model, a theoretical study was made on how the martensitic and supercondu-

cting transitions in A15 compounds influence each other. An asymmetric split-pair superconducting magnet using indigenously developed niobium-titanium wire capable of giving a central field of 4 Tesla and a peak field of 7·6 Tesla was fabricated and tested. A high-homogeneity superconducting solenoid to provide a field of 6 Tesla was wound and tested. A liquid helium cryostat with a low helium consumption rate for housing an 8-Tesla superconducting magnet was built.

In the area of High Pressure Physics, the Equations of State of Group IV elements, titanium, zirconium and hafnium were calculated using first principle electron band theory methods. The expected insulator to metal transition of materials like caesium iodide at high pressure was theoretically examined. In conformity with theoretical predictions new high-pressure phase transitions in Cd-Hg system, Pr-Th alloys and the organic compound P-$C_6H_4Cl_2$ have been found using X-ray diffraction technique. A novel phase transition in tetracyanoethylene at a pressure of 2 GPa from the ambient monoclinic phase to a cubic phase via an amorphous phase was also discovered.

Bio-Physics

A complete set of computer programs for protein crystallographic research has been implemented on the recently acquired Norsk Data computer system. For the first time, the enzyme carbonic anhydrase from the blood of the Indian buffalo has been purified by affinity chromotography techniques and has been crystallized. The structure of triclinic lysozyme has been refined to a residual error of 14·3%, which is one of the lowest that has been reported anywhere. Experiments based on NMR and calorimetric techniques were used for identifying the interaction of the antileprosy drug dapsone (DDS) with model membrane systems. A dynamical Mossbauer spectroscopic study was undertaken to investigate the photochemical oxidation-reduction processes in the iron atoms present in the respiratory pigment of rhodospirillum rubrum bacterium. It was found that the upper limit to the reversible biological switching time is about 25 milliseconds.

1·3 Reactor Physics

A major thrust was on the development work connected with the physics design of large sized (500 MWe) PHWRs. The physics analysis of these systems is far more involved than that of the existing (235 MWe) systems due to new bundle design, multiplicity of regulating and safety devices, inherent zone flux instability of the system leading to xenon oscillations and complex fuel management schemes. A number of mathematical models relating to the above were developed and verified.

Purnima II

India's first Uranium-233 fuelled experimental reactor facility PURNIMA II, which attained criticality last year, was utilised to check the reproducibility and reliability of the various control and safety devices. A comprehensive experimental study was carried out to deduce the minimum critical mass for the system. The lowest critical mass obtained was 397 gm of Uranium-233. Other investigations carried out include measurement of level coefficient of reactivity, power calibrations and reactor noise studes.

Kamini

Fabrication of most of the major components such as reactor tank, beam tubes, core internals and biological shield bricks needed for the 30 kW neutron source reactor, KAMINI, for neutron radiography at IGCAR, Kalpakkam, has reached an advanced stage. The demineraliser unit and associated pumps needed for online polishing of pool water has been installed at site. Trial fabrication of fuel alloy plates has been taken up. Prototype safety control plate drive has been fabricated and is currently undergoing testing.

1·4 Theoretical Physics

The theory of (alpha, d) reactions was developed in the framework of full ranged distorted wave born approximation (DWBA). This will help analyse data obtained from experiments with the VEC cyclotron. Non-nucleonic degrees of freedom were further analysed in the framework of DWBA. In a further study of the

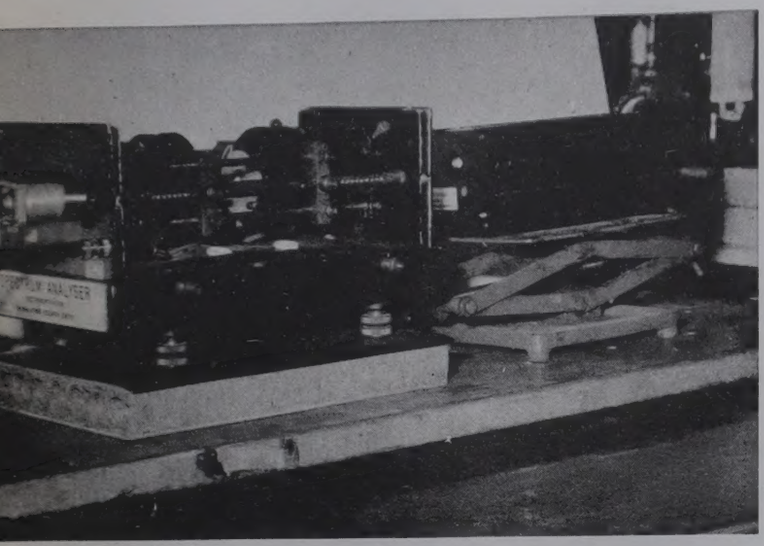
non-nucleonic degrees of freedom, the p (^{3}He, t) Δ^{++} reaction was also analysed in the framework of DWBA. Three body coupling effects were investigated from the clustering knock out reactions. Theoretical studies of the subthreshold pion production in intermediate energy heavy ion collisions were carried out. The nucleon exchange processes in heavy ion deep inelastic collisions were also theoretically investigated. The fragment angular distributions for a number of heavy ion induced reactions were analysed with the pre-equilibrium fission model developed earlier at Trombay. Detailed microscopic investigations led to the understanding of the factors responsible for sudden onset of large deformations at specific neutron number in nuclei with atomic mass around 100. New analytical results were obtained on the growth of Rayleigh-Taylor instability in multistructured shell targets of interest in inertial confinement fusion experiments. New theoretical results were obtained on the polaron problem and on the electronic density of states in disordered systems using a functional integral approach. Studies in quantum optics resulted in some exact quantum electrodynamic results on the behaviour of a Rydberg atom in a cavity and on the "squeezing" of light scattered by a three-level atom. A general relativistic formulation is being developed to study various aspects of many electron systems, particularly in heavy atoms.

Iodine Stabilised He-Ne laser

1·5 Lasers & Spectroscopy

A copper vapour laser (CVL), which is ideal for pumping dye lasers and has application in the areas of photochemistry and spectroscopy, was developed. The laser uses an alumina tube filled with helium gas which is heated to 1500°C by passing repetitively pulsed electrical discharge through it. At this operating temperature the small copper metal nodules kept in the tube get evaporated. The electrical discharge excites the copper atoms which leads to the emission of laser beam. The laser produces an average output power of 15 watts in 20 nanosecond pulses at a rate of 5,000 pulses per second. A dye laser using the CVL and a grazing incidence grating for spectral tuning and narrowing of the output was also developed. Using a solution of Rhodamine 6G dye for lasing, the dye laser gave an average output of 1·5 watt and 15 watt CVL input. The output had a spectral width of 0·06 cm^{-1} and could be tuned over a wavelength range from 570 to 610 nanometer. Other dyes can give different tuning ranges.

Instrumentation for Spectroscopy Research



Spectrum Analyser

The first five subsystems of the high power Neodymium : glass laser under development have been completed. These are a Nd : phosphate glass oscillator and four amplifiers. An output energy of 80 joules in 20 nanosecond pulses (in other words, a peak power of 4 gigawatts) was obtained.

The research programme on high resolution atomic spectroscopic studies of rare earth atoms and ions and the spectra of these ions in crystalline environment was continued. The contributions of crossed second order (CSO) effects in the spectra were investigated by analysing isotope shifts in spectral lines of some elements. Molecular spectroscopic studies were carried out in order to establish the identity of transient species produced in the flash photolysis of thiazole, isoxazole and oxazole. A number of special materials needed in nuclear, electronics and semiconductor technology were analysed. About 1050 samples involving 8,200 determinations were analysed by using optical emission spectroscopic (OES) and X-ray fluorescence (XRF) techniques. A non-dispersive infrared analyser was fabricated for the analysis of hydrogen fluoride impurity in uranium hexafluoride. The instrument can detect less than 50 ppm hydrogen fluoride. A line tunable carbon dioxide laser was fabricated for laser optogalvanic and optoacoustic studies. An experimental setup for the study of laser induced fluorescence of free radicals produced by the flash photodissociation of molecules was assembled and tested.

1·6 Seismology

The Gauribidanur Seismic Array near Bangalore continued to detect and report underground nuclear explosions and earthquakes. The array detects about 4000 seismic events annually, of which about 200 are due to nuclear explosions. A few techniques based on the time structure and spectral energy distribution of direct and core-reflected seismic signals, which were developed here for discriminating sources of explosions and earthquakes, especially the weak ones, were successfully tested on a number of "difficult" cases of explosion-like shallow-focus small earthquakes and vice versa.

A prototype single-channel wireless telemetry of seismic signals made with indigenous components was tested over a 10 km range. This will be modified to a multichannel system with a view to establishing wireless-telemetered networks for continuously monitoring seismicity of the Bhatsa dam region in Maharashtra and at other project sites in India.

1·7 Nuclear Research Laboratory, Srinagar & High Altitude Research Laboratory, Gulmarg

Two sources, Cygnus x-3 and Geminga, were tracked by the Gamma Ray Telescope at Gulmarg to detect ultra high energy gamma rays from these sources. No periodic signal was detected from Cyg. x-3 during 1984 and 1985 which is in agreement with the observations elsewhere. However, instances of gamma ray burst type signals have been observed in October, 1985 when the source was having an unusual flaring activity at radio frequencies. The source Geminga has been tracked for a total of about 50 hours. Preliminary analysis indicates a periodic emission at a period of 60·25 sec. A detailed analysis is in progress. The gamma ray telescope is also being updated with two additional mirrors of one meter diameter and a microprocessor for recording of the data.

The PANBIT gamma irradiation source was made available as a routine facility to local hospitals for the sterilization of various medical products as a part of an effort to promote radiation applications in the Kashmir valley. This facility has been also extended to Kashmir University and University of Agricultural Sciences & Technology, Srinagar, for their research programmes. A study of various elements in the 'loess-paleosol sediments' in Kashmir valley was conducted as this can provide clues to major climatic changes that could have occurred in the past 200,000 years. The study reveals that rubidium, iron, titanium, manganese, copper and zinc have generally high concentrations in clay rich horizons of past soils formed under warm humid climate whereas 'loess horizons' deposited under cold and arid climate have high concentration of calcium and strontium. Further, the concentratin of iron and titanium is considerably higher in loess profiles on Pir Panjal mountain flank compared to profiles on Himalayan mountain flank suggesting that loess minerology is controlled to a great extent by nearby rock types in the valley. A supporting facility to the multiple parameter sampling station is being set up at Gulmarg. This involves simultaneous measurements of meteorological parameters like wind speed and direction, fluctuations in ambient temperature, humidity and pressure. A simple and versatile photometer for solar radiation measurement has been further developed to correlate it with the changing concentrations of trace compounds in the atmosphere.

1·8 Variable Energy Cyclotron Centre, Calcutta

The Variable Energy Cyclotron at Calcutta operated during the year with a new schedule involving three weeks round the clock run followed by one week of maintenance/development work and this schedule was found to be very satisfactory. The utilization programme included experiments in nuclear physics, nuclear chemistry, analytical chemistry, radiation damage studies, isotope production, activation analysis, space physics studies and biophysics. Scientists from about 20 institutions such as TIFR, SINP, BARC, IGCAR, IITs and universities utilise the accelerator. Several advanced experimental set-ups like helium jet recoil transport system for investigating short-lived isotopes and gas ionization counter with 10 millisteradian solid angle to detect low energy heavy ions were developed and used in the experiments. A compton suppressed gamma-ray spectrometer with a multiplicity filter was also developed and used in experiments with the VEC beam. A number of surface barrier silicon detectors for various nuclear physics experiments were fabricated at VECC. The beam quality both in time and energy resolution was improved by developing a new technique using an unbevelled slit at the ion source. A new data acquisition system based on Norsk Data computer ND-560 with CAMAC interface was commissioned for online experiments.

1·9 Plasma Physics

In recent years, thermal plasmas at atmospheric pressures and elevated temperatures ranging from 2000 to 20,000 degrees have attracted considerable attention. Several computer codes were developed for the analysis of the thermodynamics, transport properties and dynamics of such plasmas. The modelling of plasma flow with the presence of condensed phase simulating the melting and evaporation of solids in high temperature medium, were also carried out and codes are now available for predicting the rate of evaporation. On the experimental side, the measurement of important plasma parameters like temperature, electrical conductivity, electron/ion concentration, velocity etc. in the high temperature environment need special diagnostic equipment. Several instruments were developed for this purpose. Some of these instruments were successfully used during the commissioning of the Indian MHD plant at Tiruchirapalli.

The technological applications of thermal plasmas were also explored. Plasma spraying of ceramics is one of the important areas of investigations. A novel technique for preparing several millimetre thick ceramic coatings on metals using a reinforced-pin structure was developed. Thick zirconia electrodes prepared by this technology were tested for applications in oxidizing atmospheres.

Publications

H.M. Jain, S. Kailas and S.K. Gupta, "Neutron radiative capture cross section of Th-232", *Symp. on Nuclear Physics*, Jaipur, 1985.

M.A. Prasad and K. Unnikrishnan, "Occupancy time for correlated random walks with partially absorbing boundaries", *Acta Physica Austriaca* **56** (1985) 253.

M.A. Prasad and K. Unnikrishnan, "Asymptotically exact solution of the one dimensional trapping problem with correlation", *Phys. Rev. A* **31** (1985) 523.

V.K. Panday and A.K. Ganguly, "Measurement of mono-atomic vapour concentrations of some elements by atomic absorption spectrophotometry : Cu, Ag, Au, Ma and Al", *App. Spec.* **39** (1985) 529.

V.B. Joshi, A.M. Bhagwat, H.K. Chatterji and D.D. Bhawalkar, "Laser processing of plastics : an application in nuclear particle detectors", Symp. on 'Quantum Electronics', Bombay, January 1985.

D.C. Khandekar and S.V. Lawande, "Feyman path integrals : some exact results and applications", *Phys. Repts.*(1986, in print).

D.C. Khandekar, Sunil Datta and S.V. Lawande, "Path integration of a general two-time quadratic action by prodistribution approach", *Phys. Rev. A* **31** (1985) 3574.

D.C. Khandekar, V.A. Singh, K.V. Bhagwat and S.V. Lawande, "Functional integral approach to positionally disordered systems", *Phys. Rev.* (1986, in print).

A.K. Dhara and S.V. Lawande, "Time-dependent invariants and quantum mechanics in two-dimensions", *J. Math. Phys.* (1986, in print).

S.V. Lawande, B.N. Jagtap and R.R. Puri, "Laser phase and amplitude fluctuations on the fluorescent Dicke model of interacting atoms", *J. Phys. B* **18** (1985) 1711.

D.C. Khandekar, K.V. Bhagwat and S.V. Lawande, "Exact analysis of the fluorescent Dicke model in the thermodynamic limit", *Physica* **130 A** (1985) 323.

S.V. Lawande, D.C. Khandekar, K.V. Bhagwat and B.N. Jagtap,"Exact analysis of the critical behaviour in the driven Dicke model of interacting atoms", *Physica* (1986, in print).

S.V. Lawande, R.R. Puri and Richard D'Souza, "Optical double resonance spectra and intensity-intensity co-relations under intense fields with finite bandwidths : some analytical results", *Phys. Rev. A* (1986,in print).

G.S. Agarwal and R.R. Puri, "Exact quantum-electrodynamics for scattering, emission and absorption from a Rydberg atom in a cavity with arbitrary Q", *Phys. Rev.* (1986,in print).

R.R. Puri and G.S. Agarwal, "Collapse and revival phenomena in the Jaynes-Cummings model with cavity damping", *ibid.*

N.K. Gupta and S.V. Lawande, "Pellet fusion gain calculations for spin-polarized nuclei", *Atomkernergie* **47** (1985) 191.

M.K. Srivastava and S.V. Lawande, "The rarefaction effect during coalescence of converging shocks in a laser-driven fusion", *Atomkernergie* **48** (1986) 45

N.K. Gupta and S.V. Lawande, "Rayleigh-Taylor instability in spherical geometry ", *Phys. Review A* (1986, in print).

N.K. Gupta and S.V. Lawande, "Effects of density gradients on Rayleigh-Taylor instability in an ablatively accelerated inertial confinement fusion target", *Plasma Phys. & Controlled Fusion* (1986, in print).

N.K. Gupta and S.V. Lawande, "Rayleigh-Taylor instability in multi-structured spherical targets", *Plasma Phys. & Controlled Fusion* (1986, in print).

Vinod Kumar and S.V.G. Menon, "Condensation rate on a black sphere via Fokker Planck equation", *J. Chem. Phys.* **82** (*2*) (1985) 917-920.

S.V.G. Menon and D.C. Sahni, "Convergence of discrete ordinates iteration scheme", *Transport Theory and Statistical Physics* **14** (*3*) (1985) 353-372.

V.C. Boffi, G. Spiga, S.V.G. Menon and M.K. Srivastava, "Critical problem for slabs with sinusoidally space-dependent scattering ratio", *ibid.*, 373-382

S.V.G. Menon and D.C. Sahni, "Derivation of the diffusion equation and radiation boundary condition from the Fokker Planck equation", *Phys. Rev. A*(Rapid Communications) **32** (*6*) (1985) 3832-3834.

S.V.G. Menon, "Solution of the nonlinear Boltzmann equation for test particle diffusion with removal effects", *Physics Letters A* **113** (*2*) (1985) 79-81.

S.V.G. Menon, Vinod Kumar and D.C. Sahni, "Green's function approach to the solution of the time dependent Fokker-Planck equation with absorbing boundary", *Physica A* (in print).

S.V.G. Menon, "Reduced description of Brownian motion in a half space with a partially absorbing boundary", *Physics Letters A* (in print).

V. Jagannathan, "Application of the finite-element-synthesis model to multi-dimensional reactor transient problems without feedback", *Annals of Nuclear Energy* **12** (1985) 583-591.

Subhash Chandra, "The influence of the particle phase size on the disassembly transient in fast reactors", *Nucl. Tech.* (in print).

H.P. Gupta and M.S. Trasi, "Asymptotically stable solutions of point-reactor kinetics equations in presence of Newtonian temperature feedback", *Annals of Nuclear Energy* (in print).

D.P. Burte and S.G. Vaidya, "Sector symmetric core concept for boiling water reactors", *ibid.*

V. Jagannathan, "An analysis of multidimensional reactor transients by using reduced integration techniques in finite element method", *ibid.*

P.D. Krishnani, "Transformation law for probabilities in interface current method and its application to burnup calculations", *Annals of Nuclear Energy* **12** (1985) 675-680.

P.D. Krishnani, "Analysis of PHWR lattice experiments with organic coolant by the computer code CLUB", *ibid.* 319.

V.K. Jain and H.P. Gupta, "Analysis of super delayed-critical transients in thermal reactors using 2-, and 3-dimensional adiabatic and improved quasistatic models", *ibid.* **13** (*3*) (1986).

H.C. Gupta and S.R. Dwivedi, "Sampling of scattering angle in deep-penetration Monte Carlo",*ibid.*, **12** (1985) 213-216.

S.R. Dwivedi and H.C. Gupta, "Biasing parameter limits for synergestic Monte Carlo in deep-penetration calculations", *Nucl. Sci. Engg.* (in print).

V. Jagannathan, P. Mohanakrishnan, K.R. Srinivasan, Vinod Kumar, R. Srivenkatesan, V. Balraman, S.G. Vaidya and B.P. Rastogi, "Nuclear design report - Tarapur 7 × 7 reload-3 fuel", *B.A.R.C.-1258* (1985).

P. Mohanakrishnan and V. Jagannathan, "TREDIT - A 3-D multigroup diffusion theory simulator for hexagonal fuel assembly cores", *B.A.R.C.-1261* (1985).

V. Jagannathan, "FEYMSYN - A code system to solve multigroup diffusion theory equations using a variety of solution techniques", Part 1 : Description of code system - input and sample problems, *B.A.R.C.-1265* (1985).

ibid, Part 2 : DIFXYZ - The finite difference modules, *B.A.R.C.-1266* (1985).

ibid. Part 3: FINERC - The finite element modules, *B.A.R.C.- 1267* (1985).

ibid, Part 4: SYNTHD: The synthesis module, *B.A.R.C.-1268* (1985).

D.P. Burte and S.G. Vaidya, "Low incremental control worth reload patterns for BWRs", *B.A.R.C.-1288* (1985).

B.P. Rastogi, S.V.G. Menon and R.P. Jain, "Annual progress report for 1984 of theoretical physics division", *B.A.R.C.-1263* (1985).

H.C. Gupta, "Importance biasing scheme for expectation estimator in deep-penetration problems", Ph.D. Thesis, University of Bombay (1985).

R. Srivenkatesan, V. Balaraman and K.R. Srinivasan, "Comparison of 500 MWe PHWR simulations by TAQUIL and FEMINA", *PHWR 500/PHY/3* (1985).

R. Srivenkatesan, T. Mukhopadyay, P.D. Krishani, Vinod Kumar, S.D. Paranjpe and H.C. Huria, "Zone controller simulation for 500 MWe PHWR reactor", *PHWR 500/PHY/4* (1985).

P.D. Krishnani, "Two group lattice parameters for 500 MWe PHWR", *PHWR 500/PHY/5* (1985).

P.D. Krishnani, "Effect of pressure tube thickness on reactivity of 500 MWe PHWR", *PHWR 500/PHY/6* (1985).

S.V.G. Menon, K.R. Srinivasan and R. Srivenkatesan, "Evaluation of homogenisation errors in a typical lattice" *PHWR 500/PHY/7* (1985).

A.N. Nakra, "Representative bundle power envelopes for CANDU reactors - Canadian results", *PHWR 500/PHY/8* (1985).

K.R. Srinivasan, "Revised burnup estimate for the 500 Mw(e) PHWR", *PHWR 500/PHY/9* (1985).

R. Srivenkatesan, V. Balaraman, V.K. Jain and K.R. Srinivasan, "PHWR benchmark analysis with DIMENTRI, THREED and FEMINA", *PHWR 500/PHY/10* (1985).

A.N. Nakra and R. Srivenkatesan, "Burnup optimization with larger inner zone radius for 500 MW(e) PHWR", *PHWR 500/PHY/11* (1985).

R. Srivenkatesan, P. Mohanakrishnan and K.R. Srinivasan, "Instrumented channels for the 500 MWe reactors", *PHWR 500/PHY/12* (1985).

S.B. Degwekar, "Adjuster rod's worth for 500 MW(e) PHWR - supercell calculations", *PHWR 500/PHY/13* (1985).

Arvind Kumar and R. Srivenkatesan, "Spatial xenon oscillations in large PHWRs", *PHWR 500/PHY/14* (1985) and *Th.P.D./308* (1985).

R. Srivenkatesan, "Deputation report - deputation to Argentina during Aug. 23 to Sept. 23, 1985", *PHWR/PHY/15* (1985).

P.D. Krishnani, "Analysis of experiments with 37-rod fuel cluster in ZED-2 Reactor", *PHWR/PHY/16* (1986).

P.D. Krishnani, "Revised lattice parameters for 500 MWe PHWR", *PHWR/PHY/17* (1986).

D.P. Burte, V. Jagannathan, K.R. Srinivasan and S.G. Vaidya, "Tarapur Unit-1 Cycle-10 fuel management report", *FM Report U-1/c-10* (1985).

H.D. Purandare, "Defuelling studies for RAPS-1", *Th. P.D./HPD/655* (1985).

R. Srivenkatesan, S.U. Kamat and H.D. Purandare, "NAPP Secondary shutdown system banking", *Th.P.D./307* (1985).

S. Das, "Dynamic behaviour of a reactor in the presence of an extraneous neutron source", Proceedings of the workshop on reactor noise analysis, IGCAR, Kalpakkam, I-5 (1985) 76-93.

B.P. Rastogi, "Nuclear data for nuclear power programme", IAEA Interregional Training Course on Preparation of Nuclear Data for Use in Reactor Calculation, Bombay, March 31-April 25, 1986.

H.C. Huria, "Processing of resonance data for thermal reactors", *ibid.*

P.D. Krishnani, "Validation of nuclear data for heavy water power reactor lattices", *ibid.*

P. Mohanakrishnan, "Experience of analysing integral experimental systems moderated by light water to determine adequacy of nuclear data and computational methods", *ibid.*

Arvind Kumar, H.P. Gupta, V.K. Jain and R.S. Modak, "Multidimensional core kinetics analysis for LWRs and PHWRs", Paper presented in the Indo-FRG seminar on reactor safety, Bombay (1985).

S. Das, "Review of the book 'History of Science and Scientific Method," Ganita-Bharati, *Bulletin of the Indian Society for History of Mathematics, 6(1-5)* (1985) 47-50.

P.K. Chakraborti, R. Talukdar, P.N. Bajaj, A. Joshi and V.B. Kartha, "Relaxation in pure and seeded supersonic jets of SF_6", *Chem. Phys.* **95** (1985) 145.

V. Parthasarathy, S.K. Sarkar, K.V.S. Rama Rao and J.P. Mittal, "IR laser photolysis of CDF_3 : role of buffer gas on selectivity and yield for deuterium enrichment in fluoroform", *J. Photochemistry* **39** (1985) 333.

S.V. Lawande, B.N. Jagtap and R.R. Puri, "Laser phase and amplitude fluctuations of the fluorescent Dicks model of interacting atoms", *J. Phys. B* **18** (1985) 1711.

B.M. Suri, R. Kapoor, G.D. Saksena and P.R.K. Rao, "Systematic trends in optogalvanic signals of some transitions in a uranium hollow cathode discharge", *Opt. Comm.* **52** (1985) 315.

P.K. Chakraborti, "Rare gas dimers in a nozzle beam", *Pramana, J. Phys.* **25** (1985) 191.

B.M. Suri, R. Kapoor and G.D. Saksena, "Wavelength control of a pulsed dye laser using optogalvanic effect", *J. Phys. (E) 18* (1985) 930

K.B. Thakur, V.A. Job and V.B. Kartha, "Diode laser spectrum and analysis of the ν_{15} band of s-tetrazine", *J. Mol. Spectroscopy* **112** (1985) 340.

K.V.S.R. Apparao, N.K. Sahoo and T.C. Bagchi, "Low lose ZrO_2 films for optical application in the UV-region", *Thin Solid Films* **129** (1985) 71.

L.G. Nair and K. Dasgupta, "Amplified spontaneous emission in narrow band pulsed dye laser oscillators - theory and experiment", *IEEE J. Quant. Elec.* (Nov. 1985).

P.R.K. Rao, "High resolution spectroscopy of atoms and molecules using lasers", *Instr. Bulletin* (Third Quarter) (1985) 30-34.

B.N. Jagtap, G.K. Bhowmick, K.G. Manohar and V.B. Kartha, "Spectroscopic investigations of three step photoionization of uranium", *BARC/R-3* (1985).

K.V.S.R. Apparao and N.K. Sahoo, "Design and development of a thin film dielectric beam combiner", National Seminar on Thin Film Science and Technology, IISc., Bangalore, January 9-11, 1985.

P.K. Chakraborti, "Laser diagnostic and relaxation studies in a supersonic flow", DST Workshop on 'Update in Inorganic and Physical Chemistry', Indian Institute of Science, Bangalore, January 13-14, 1985.

K.V.S.R. Apparao, N.K. Sahoo and T.C. Bagchi, "Low loss high index thin film materials for UV laser applications", Symp. on Quantum Electronics, BARC, January 14-16, 1985.

S.D. Sharma, A.K. Ray and G.D. Saksena, "Two-photon excitation $E^3\pi_0{}^+g$ ion-pair state of iodine", *ibid.*

B.M. Suri, R. Kapoor, G.D. Saksena and P.R.K. Rao, "Optogalvanic studies in a uranium hollow cathode using pulsed dye laser", *ibid.*

B.N. Jagtap, R.R. Puri and S.V. Lawande, "Analytical results on absorption spectrum of two interacting two level atoms in fluctuating laser field", *ibid.*

B.N. Jagtap, R.R. Puri, S.V. Lawande, "Laser phase and amplitude fluctuations in cooperative fluorescence of interacting atoms," *ibid.*

K.G.Manohar, G.K. Bhowmic, B.N. Jagtap and V.B. Kartha, "Studies of homogeneous line broadening in uranium vapour by saturated absorption spectroscopy", *ibid.*

R.K. Talukdar, A. Joshi, P.N. Bajaj, V.B. Kartha and P.K. Chakraborti, "Laser study of rotational relaxation in pure and seeded jets of sulphur hexafluoride", *ibid.*

M.S. Bhatia, B.M. Suri and R. Kapoor, "Noise consideration in laser optogalvanic spectroscopy using hollow cathode discharge", *ibid.*

K.V.S.R. Apparao, N.K. Sahoo and T.C. Bagchi, "Optical thin film technology for lasers", *ibid.*

V. Parthasarathy, S.K. Sarkar, K.V.S. Rama Rao and Jai P. Mittal, "Selective IR laser photochemistry of CDF_3 in natural fluoroform", *ibid.*

K.V.S.R. Apparao, N.K. Sahoo and T.C. Bagchi, "Optical constants of ZrO_2 film in the UV region", IPS National Seminar on Solid State Physics, Jadavpur University, Calcutta, Feb. 14-17, 1985.

P.N. Bajaj, S.K. Sarkar, R.K. Talukdar, K.V.S. Rama Rao, J.P. Mittal and P.K. Chakraborti, "Infrared laser induced multiphoton dissociation of large uranium bearing molecules", 3rd National Symposium on Mass Spectrometry - Research, Applications and Instrumentation, Regional Engg. Laboratory, Hyderabad, Sept. 22-24, 1985.

M.S. Bhatia, "Optimum shape of a two-coil system for maximum field", Paper sent to 9th International Conf. on Magnet Technology, SIN, Zurich, Switzerland, 9-13 Sept., 1985.

A.K. Ray, S.D. Sharma and G.D. Saksena, "Study of 'Bound-Free' transitions", National Conference on Spect. & Theo. Chem. University of Calcutta, Dec. 5-7, 1985.

G.K. Bhowmick, R.K. Talukdar, P.N. Bajaj, P.K. Chakraborti and V.B. Kartha, "Associative ionization of uranium with oxygen in presence of resonant laser radiation", *ibid.*

R.K. Talukdar and P.N. Bajaj, "IR diode laser study of jet profile and condensation in supersonic flow of NH_3", *ibid.*

P.N. Bajaj and P.K. Chakraborti, "Condensing flow in pure and seeded supersonic jets of SF_6," *ibid.*

P.N. Bajaj, R.K. Talukdar, A. Joshi, P.K. Chakraborti and V.B. Kartha, "Infrared diode laser study of SF_6 in seeded supersonic jets", *ibid.*

S.K. Sarkar, V. Parthasarathy, K.V.S. Rama Rao and J.P. Mittal, "Pulsed optoacoustic measurements of TEA-CO_2 laser induced multiphoton excitation in fluoroform-d," *ibid.*

M.R. Kale and R. Kapoor, "Design and fabrication of a hollow cathode discharge tube for optogalvanic spectroscopy", Fourth Annual Seminar of Indian Society of Scientific Glass Blowers, IIT Kanpur, Dec. 5-7, 1985.

"Seismic analysis of ventilation stack", International Conference on Finite Elements in Computational Mechanics, IIT Bombay, 2-6 Dec., 1985.

T.P.S. Nathan, S.M. Oak, A.S. Joshi and D.D. Bhawalkar, "Generation of modulation free pulses using an active etalon", *Optics Communication* **57**(*1*) (1986) 69.

P.K. Bhattacharya, M.J. Kansara, T.P.S. Nathan, P. Singh and A.G. Wagh, "Investigation of laser-annealed antimony implanted Si by ion backscattering and channeling and structure analysis", *App. Phys. A* **39** (1986) 147-154.

J.C. Monga, J.S. Uppal and D.D. Bhawalkar, "Collimation of output beam from an asymmetric unstable ring laser", *Appl. Opt.* **24** (1985) 914.

J.S. Uppal, T.P.S. Nathan and D.D. Bhawalkar, "Performance characteristics of Nd: glass laser amplifier from fluorescence emission studies", *Opt. Quantum Electron* **17** (1985) 323.

J.S. Uppal and J.C. Monga, "Comment on thermal transient effects in silicate and phosphate rods pumped in pseudoeliptic close-coupled cavities", *Opt. Commun.* **56** (1985) 179.

J.S. Uppal, J.C. Monga and D.D. Bhawalkar, "Performance of general asymmetric unstable ring laser", *Appl. Opt.* **25** (1986) 97.

J.S. Uppal, J.C. Monga and D.D. Bhawalkar, "A simple method for the alignment of ring resonator", *Opt. Laser Tech.* **17**(1985) 215.

J.S. Uppal and J.C. Monga, "Contribution of stress dependent variation of refractive index towards thermal lensing in Nd : glass laser rods", *Appl. Opt.* **24** (Nov. 1985).

Vasdev, U. Nundy, D.J. Biswas, N.S. Shikarkhane and U.K. Chatterjee, "Frequency stabilization of a cw-CO_2 laser", Proc. Symp. Quantum Electronics, BARC, Jan. 14-16, 1985; 85-87.

P. Das, U. Nundy, and U.K. Chatterjee, "Spatial intensity profile of the output beam in a telescopic CO_2 amplifier", *ibid.* 100-105.

N.S. Shikarkhane, U. Nundy and U.K. Chatterjee, "Simple circuit to passively synchronize the predischarge and main discharge in a UV preionized TEA CO_2 laser", *Rev. Sci. Instrum.* **56**(3) (1985) 474-476.

L.M. Kukreja, S.K. Sehgal and U.K. Chatterjee, "Pulsed operation of a longitudinal CO_2 laser without a ballast impedance", *ibid.* **56**(*11*) (1985) 2021-2025.

L.M. Kukreja, S.K. Sehgal and U.K. Chatterjee, "On obtaining wide range 30 usec.-5 msec. adjustable pulse duration from a longitudinally excited CO_2 laser", Proc. Symp. on Quantum Electronics, BARC, 1985; 112-115

L.M. Kukreja, V.B. Joshi, A.M. Bhagwat, U.K. Chatterjee and D.D. Bhawalkar, "Laser processing of plastics - an application in nuclear particle detection", *ibid.*, 305-308.

"125 Watt cw-CO_2 laser, its pulsed operation and tuning", *B.A.R.C/I-859* (1986).

L.G. Nair and K. Dasgupta, "Amplified spontaneous emission in narrow-band pulsed dye laser oscillators - theory and experiment pulsed dye laser", *IEEE J. Quant. Elec., QE-21(11)* (1985) 1782.

K. Dasgupta and L.G. Nair, "Reduction in ASE in grating-incidence-grating dye laser oscillator by pump pulse shaping", Proc. Symp. on Quantum Electronics, BARC, Jan. 1985; 55.

J.K. Mittal, P.K. Bhadhani, B. Singh and R. Bhatnagar, "Copper vapour laser-A status report", *B.A.R.C/I-855* (1985)

S. Dutta and P.K. Gupta, "Rate-equation model for a hybrid CO_2 laser", Proc. Symp. on Quantum Electronics, BARC, 1985; 106-111.

P.K. Gupta, "Lasers and their effects on biological systems", *Bulletin of Radiation Protection* **8** (1985) 19-37.

Sucharita Dutta and K.C. Rustogi, "Spectral shifts in composite materials", DAE Symp. on Solid State Physics, Dec. 1985.

K.C. Rustogi, "Saturation of degenerate four wave mixing", *ibid.*

B.D. Bhawe and J.C. Monga, "Role of spectral matching in optimization of the design of low light level imaging systems", *Applied Optics* **24**(*14*)(15 July 1985) 2103-08.

J.C. Monga and B.D. Bhawe, "Optimization considerations in the design of active night viewing systems", *Optics and Laser Technology*, (Aug. 1985) 201-204.

J.C. Monga, "Design of multilayer thin film polarizers with extended wavelength response", Proc. Symp. on Quantum Electronics, Bombay, Jan. 1985, 301- 304.

L.J. Dhareshwar, P.A. Naik and H.C. Pant, "Determination of density profiles in a laser produced plasmas and study of laser irradiated thin foil hydrodynamics using an optical probe beam", Proc. of Workshop on Plasma Diagnostics, Jan. 1986.

S.R. Kumbhare, P.A. Naik and H.C. Pant, "Ballistic and torsion pendulums for momentum measurement of laser produced plasmas", *ibid.*

S. Sharma, T.S. Shirsat and H.C. Pant, "Calorimetric study of laser produced plasmas from solid targets", *ibid.*

P.A. Naik, P.D. Nandwana, S.R. Kumbhare and H.C. Pant, "K. Edge spectrometer for laser-plasma studies", *ibid.*

S. Sharma, "A fast vacuum X-ray photodiode", *ibid.*

S. Sharma, "X-ray imaging of laser-produced plasmas (Review)", *ibid.*

L.J. Dhareshwar, "Optical probing of laser-produced plasmas (Review)", *ibid.*

P.A. Naik and H.C. Pant, "X-ray spectroscopy of laser-produced plasmas (Review)" *ibid.*

R.K. Khardekar, "Role of data acquisition and management techniques in laser - plasma interaction studies (Review)", *ibid.*

H.C. Pant, "Recent laser fusion experiments (Review)", Third National Symp. on Science and Technology of Plasmas, Jaipur, Oct. 1985.

P.A. Naik, L.J. Dhareshwar, P.D. Nandwana and H.C. Pant, "Effect of irradiation assymmetry on the stability of laser driven thin foil targets", *ibid.*

L.J. Dhareshwar, P.A. Naik, P.D. Nandwana and H.C. Pant, "Effect of target assymmetry on the stability of laser driven thin foil targets", *ibid.*

H.C. Pant, "Physics of coronal plasma (Invited talk)", Spring College in Plasma Physics, International Centre for Theoretical Physics, Triste (Italy), May-June (1985).

Vas Dev, U. Nundy, N.S. Shikarkhane, P.K. Gupta and U.K. Chatterjee, "Thermal effects of intracavity optical components on the power tuning curve in a cw-CO_2 laser, *Opt. Commun.* **57** (15 Feb. 1986).

Z.S. Horvath, R.M. Barnes and P.S. Murthy, "Iminodiacetic acid/ethyl cellulose as a chelating ion exchanger; Part-2 : Determination of trace metals by inductively coupled-plasma atomic emission spectrometry", *Anal. Chim. Acta* **173** (1985) 305.

N.P. Karanjikar, R.C. Naik,V.P. Bellary and T.K. Balasubramanian, "Spectroscopic investigations of Pr^{3+} in $GdPO_4$ and observation of antistokes fluorescence", *Ind. J. Phys.* **59A** (1985) 417.

Pushpa M. Rao, A. Venugopalan, S.A. Ahmad and G.D. Saksena, "Isotope shift studies in the first spectrum of erbium in the region 3900-4600 *A*°, *Ind. J. Pure & Appl. Phys.* **23**(1985) 208.

R. D'Cunha, S. Urban, K. Narahari Rao, L. Henry and A. Valentin, "The ν_2 band of $^{15}NH_3$", *J. Mol. Spectrosc.* **111** (1985) 352.

S. Urban, R. D'Cunha, K. Narahari Rao and D. Papousek, "The $\Delta K = \pm 2$ perturbation-allowed υ_4 band and in version-rotation energy levels of $^{15}NH_3$", *ibid.*, 361.

G. Lakshminarayana, B.J. Shetty and Sheila Gopal, "Rational analysis of the $E^1\sum^+ - X^1\sum^+$, bands of SiS", *ibid.*, **112**

K.B. Thakur, V.A. Job and V.B. Kartha, "Diode laser spectrum and analysis of ν_{15} band of S-Tetrazine", *ibid.* 340.

L.C. Chandola and P.P. Khanna, "X-ray fluorescence spectrometric analysis of erbium oxide for rare-earth impurities", *J. Radio Anal. & Nucl. Chem.* **71** (1985) 157.

R. Neugart, H.H. Stroke, S.A. Ahmad, H.T. Duong, H.N. Ravn and K. Wendt, "Nuclear magnetic moments of ^{207}Tl", *Phys. Rev. Letts.* **5** (1985) 1559.

T.K. Balasubramanian and V.P. Bellary, "Rotational line strengths in $^4\sum - ^4\pi$ transitions of diatomic molecules", *Pramana* **24** (1985) 503.

Pushpa M. Rao, A. Venugopalan, S.A. Ahmad and G.D. Saksena, "Isotope shift studies and electronic configuration assignment to the energy levels of neutral erbium", *Spectrochim. Acta.* **40B** (1985) 1059.

S.L.N.G. Krishnamachari and R. Venkatasubramanian, "Electronic absorption spectra of HNC and DNC", *Spectr. Letts.* **19** (*1*)(1986) 55.

S.A. Ahmad, W. Klempt, C. Ekstrom, R. Neugart and K. Wendt, "Nuclear spins, moments and changes of the mean square charge radii of 140-153 Ea", *Z. Phys. A.* **321** (1985) 15.

R.M. Dixit and S.S. Deshpande, "X-ray fluorescence method for the determination of potassium, rubidium and cesium in thoria", *B.A.R.C.-1252* (1985).

M.J. Kamat, R. Kaimal and S.K. Malhotra, "Determination of trace impurities in mullite–A dc arc spectrographic method", *B.A.R.C.- 1264* (1985).

L.C. Chandola and P.P. Khanna, "Lutetium oxide/oxalate of rare earth impurities", *B.A.R.C.- 1264* (1985).

R.M. Dixit and S.S. Deshpande, "X-ray fluorescence determination of Pr, Nd, Sm, Gd, Tb, Dy and Y in high purity europium oxide", *B.A.R.C.-1275* (1985)

V.B. Kartha, N.D. Patel and S. Venkateswaran, "A non-dispersive infrared analyser for analysis of HF in ppm range", *B.A.R.C. -1285* (1985)

S.A. Ahmad, "Laser spectroscopy of short lived isotopes-A review", *Ind. J. Phys.* (in print).

K.V.S.R. Apparao, N.K. Sahoo and T.C. Bagchi, "Optical constants of ZrO_2 films in the U.V. region", *ibid.*

T.K. Balasubramanian and V.P. Bellary, "Rotational intensity factors for $^4\sum - ^4\sum$ transition in diatomic molecules with $^4\sum$ displaying Hund's case C' tendency", *ibid.*

S.L.N.G. Krishnamachari and R. Venkatasubramanian, "Absorption spectra of CCSH and CCSD radicals", *ibid.*

S. Urban, R. D'Cunha, J. Manheim and K. Narahari Rao, "High J transitions in the ν_2 bands of $^{14}NH_3$ and $^{15}NH_3$", *J. Mol. Spectrosc.* (in print).

L.C. Chandola and P.P. Khanna, "Determination of rare earth impurities in ytterbium oxide by X-ray flourescence spectrometry", *Mikrochimica Acta.* (in print).

L.V. Lavande, R.R. Puri and R. D'Souza, "Optical double resonance spectra and intensity correlation under intense fields with finite band widths, some analytical results", *Phys. Rev. A.* (in print).

M. Singh, B.M. Suri, R. Kapoor, G.D. Saksena and P.R.K. Rao, "Rotational

structure in the XeCl laser bands at 308 nm", *Spectr. Letts.* (in print).

Madan Lal, R.K. Choudhary and R.M. Agarwal "Optimisation of geometry for X-ray analysis of materials in the rare-earth region", *X-ray Spectrometry* (in print)

T.K. Balasubramanian and V.P. Bellary, "Intensity distribution in rotational structure of $^1\Delta - ^3\Sigma$ and $^1\pi - ^3\Sigma$ transitions in diatomic molecules", *Acta Physica Hungarica* (Communicated).

K.V.S.R. Apparao, N.K. Sahoo and T.C. Bagchi, "Optical losses of ZrO_2 films in the UV region", *J. Pure & Appl. Phys.*(Communicated)

G. Lakshminarayana and B.J. Shetty, "Rotational analysis of the $a^3\pi - X^1\Sigma^+$ bands of GaD", *J. Mol. Spectrosc.* (Communicated).

S.A. Ahmad, W. Klempt, R. Neugart, E.W. Otten, K. Wendt and C. Ekstrom, "Nuclear charge radii of radium isotope and their relation to octupole deformation in 222-228 Ra region", *Nucl. Phys. A*(Communicated).

K. Wendt, S.A. Ahmad, W. Klempt, R. Neugart, E.W. Otten and H.H. Stroke, "On the hyperfine structure and isotope shift in Ra", *Z. Phys. A* (Communicated).

S.A. Ahmad, "Fast beam laser spectroscopy of atoms and molecules", Symp. on Quantum Electronics, BARC, Bombay, Jan. 14-16, 1985.

S.A. Ahmad, "Laser spectroscopy for characterisation of materials", National Seminar on Characterisation of Materials, Delhi, Sept. 16-18, 1985.

R.M. Agrawal, "X-ray fluorescence determination of rare-earths experimental evaluation of various cases of spectral overlap", National Seminar on X-ray Spectroscopy and Related Areas, Nagpur, Oct. 27-29, 1985.

V.B. Kartha, "Fourier transform spectroscopy", "Analytical applications of optogalvanic spectroscopy" and "Techniques and applications of optogalvanic spectroscopy", Workshop on analytical spectroscopy, I.G.C.A.R., Madras, Oct. 31 - Nov. 2, 1985.

V.B. Kartha, "Laser spectroscopic techniques in molecular dynamics", Seminar on 'Current Awareness in Radiation and Photochemical Sciencess', Ind. Soc. Rad. Photochem. Science, Bombay, Nov. 25, 1985.

V.B. Kartha, "Techniques and applications of tunable diode laser spectroscopy", National Conf. on Spectroscopy and Theoretical Chemistry, Calcutta, Dec. 5-7 1985.

S.A. Ahmad, C. Ekstrom, W. Klempt, R. Neugart and K. Wendt, "Nuclear spins and moments of odd-A isotopes of erbium studies by collinear fast beam laser spectroscopy", Symp. on Quantum Electronics, BARC, Bombay, Jan. 14-16, 1985.

T.K. Balasubramanian, G.L. Bhale and V.P. Bellary, "On the gain co-efficient of N_2 (u.v.) laser", *ibid.*

M.N. Dixit, M.B. Guhagarkar, A.S. Rao and S.D. Sharma, "A compact nitrogen laser for pumping tunable dye lasers", *ibid.*

N.P. Karanjikar, R.C. Naik, V.P. Bellary and T.K. Balasubramanian, "Laser excited fluorescence of Pr^{3+} in $LaPO_4$", *ibid.*

S.V. Lawande, R.R. Puri and R. D'Souza, "Optical double resonance spectra in the presence of laser phase fluctuations", *ibid.*

Q.V. Lawande, R. D'Souza and S.V. Lawande, "Co-operative effects in optical double resonance", *ibid.*

K.G. Manohar, G.K. Bhowmick, B.N. Jagtap and V.B. Kartha, "Studies on homogeneous line broadening in uranium vapour by saturated absorption spectroscopy", *ibid.*

R.R. Puri, S.V. Lawande and R. D'Souza, "Effect of finite excitation band widths on optical double resonance", *ibid.*

S.D. Sharma, A.K. Ray and G.D. Saksena, "Two photon exicitation of $E^3\pi/O_g^+$ ion pair state of iodine", *ibid.*

R. D'Souza, R.R. Puri and S.V. Lawande, "Optical double resonance under intensifields", *ibid.*

R.K. Talukdar, A. Joshi, P.N. Bajaj, V.B. Kartha and P.K. Chakraborti, "Laser study of rotational relaxation in pure and seeded jets of sulphurhexafluoride", *ibid.*

T.V. Venkitachalam, "Photodissociation of SO_2: production and detection of fragments at the photolysing frequencies", *ibid.*

N.P. Karanjikar, R.C. Naik, V.P. Bellary and T.K. Balasubramanian, "Spectroscopic investigations of Pr^{3+} in $GdPO_4$ and observation of antistokes fluorescence", National Seminar on Solid State Physics, IACS, Jadavpur, Feb. 14-19, 1985.

K.S.V. Nambi and A.V. Sankaran, "ESR dating of laterites of basaltic origin", International Symp. on ESR dating, Ube Japan, Sept. 1985.

S. Urban, R. D'Cunha and K. Narahari Rao, "Forbidden transitions in the ν_2 bands of ammonia", 9th Colloquium of High Resolution Molecular Spectroscopy, Riccione, Sept. 16-20, 1985.

R.M. Agrawal and S.K. Malhotra, "Composition of Pt-Rb Alloy-A modified solution dillution X-ray fluorescence method", National Seminar on X-ray Spectroscopy & Related Areas, Nagpur, Oct. 27-29, 1985.

R.M. Agrawal and S.K. Kapoor, "Effect of some important sample parameters on the X-ray fluorescence determination of trace impurities in high purity materials", *ibid.*

P.S. Murty and S.V.N. Bhaskara Rao, "Effect of surface charging on the half width of Ga $2P_{3/2}$ photoelectron line", *ibid.*

T.K. Balasubramanian, G.L. Bhale, Sheila Gopal, G. Krishnamurty, G. Lashminarayana, P. Saraswathy, B.J. Shetty and M. Singh, "High resolution spectral studies of some diatomic molecules of astrophysical interest", IAU Symposium No. 120 on Astrochemistry, Goa, Dec. 3-7, 1985.

R. D'Cunha, S. Urban and K. Narahari Rao, "Long path fourier transform spectra of ammonia", *ibid.*

S.L.N.G. Krishnamachari, T.V. Venkitachalam and R. Venkatasubramanian, "Spectra of some polyatomic free radicals and their astrophysical applications", *ibid.*

V.P. Bellary and T.K. Balasubramanian, "Rotational intensity factors of spin forbidden transitions in diatomic molecules", National Conf. on Spectroscopy and Theoretical Chemistry, Calcutta, Dec. 5-7, 1985.

G. Lakshminarayana and B.J. Shetty, "Rotational analysis of the $a^3\pi - X^1\Sigma^+$ band of GaD", *ibid.*

S.A.Ahmad, "Odd-even staggering of nuclear charge radii in the region of shell closure and shape transition". Symp. on Nucl. Physics. Jaipur. Dec. 1985

S.A. Ahmad, "Isotope shift studies in atomic spectra-relativistic J-dependence and crossed second order field shifts", LAMP III Conference ICTP, Trieste, Italy, 1985.

S.A. Ahmad, "Investigation of short lived nuclei using lasers", *ibid.*

P.S. Murthy, "Separation of some trace metals from high purity magnesium using a chelating resin and their determination by ICP AES", National Symp. on Separation Techniques with Satellite Symp. on Solvent

Extraction & Ion Exchange, Waltair, Jan. 9-11, 1986.

S.K. Kataria, "Deformation and shell dependent nuclear level density formula", *Nucl. Phys. A* **437** (1985) 397-406.

S. Kailas, S.K. Gupta, S.S. Kerekatte and C.V. Fernandes, "$^{51}V(P,n)^{51}Cr$ reaction from E_p 1·9 to 4·5 MeV", *Pramana* **24** (1985) 629.

S.K. Gupta, S. Kailas, N. Lingappa and A. Shridhar, "Systematics in the volume integrals of the imaginary part of the light ion optical potentials", *Phys. Rev. C* **31** (1985) 1965.

S.K. Gupta, "Optimization of beam transmission through two-slit collimating systems", *Nucl. Instr. & Meth. for Physics Research A* **239** (1985) 152.

A.G. Wagh and S.K. Gupta, "From Nuclear stopping to interatomic potentials via the power law formalism", *Phys. Lett.* **108 A** (1985) 391.

S.K. Samaddar, J.N. De and K. Krishan, "Thermal equilibrium in strongly damped collisions", *Phys. Rev. C* **31** (1985) 1053.

J.N. De and S.S. Kapoor, "On the influence of shell structure of single-particle levels in dissipative heavy ion collisions", *Nucl. Phys. A* **440** (1985) 152.

J.N. De, K. Krishan and S.K. Samaddar. "The effect of shell gap in strongly damped collisions", *Nucl. Phys. A* **445** (1985) 173.

B.K. Jain, "(^{3}He, t) reaction in the Δ-isobar region", *Phys. Rev. C* **32** (1985) 1253.

R. Shyam and M.A. Nagarajan, "A distorted-wave-born-approximation theory of heavy-ion induced projectile break-up reaction", *Ann. Phys.* **163** (1985) 265.

Kuldeep and Animesh K. Jain, "Stopping cross-sections of He^+ ions in bismuth", *Nucl. Instrum. Meth. B* **9** (1985) 259.

S. Kailas, "Thermonuclear reaction rates from (p,n) reactions on targets with A = 92-122", *Indian Journal of Astrophysics & Astronomy* (in print).

S. Kailas and S.K. Gupta, "Nucleus-nucleus potential from fusion and elastic scattering", *Phys. Rev. C* (in print).

Hashima Hasan and B.K. Jain, "Energy dependence of the ^{6}Li (P, Δ^{++}) ^{6}He reaction", *Phys. Rev.* (in print).

Madan Lal, R.K. Choudhary and R.M. Agarwal, "Optimisation of geometry for X-ray analysis of materials in the rare earth region", *X-ray Spectrometry* (in print).

K.N. Iyengar, R.P. Anand, N.N. Ajitanand, D.M. Nadkarni and A.K. Mohanty, "Anomalous behaviour of sub-coulomb proton induced fission cross-section of U-235 and U-238", Symp. on Nuclear Physics, **28B** (1985) 352.

R.P. Anand, K.N. Iyengar and N.N. Ajitanand, "Measurement of the fast neutron fission cross section of Th-232 relative to U-238", *ibid.*, 350.

N.N. Ajitanand and J.M. Alexander, "Characteristics of evaporative emission from deformed nuclei", *ibid.*, 348.

R. Varma, G.K. Mehta, A. Saxena, Aruna Nijasure, R.K. Choudhry, S.S. Kapoor and V.S. Ramamurthy, "Fragment mass and kinetic energy correlation studies in alpha induced fission of ^{235}U", *ibid.*, 30.

A. Saxena, R.K. Choudhary, S.S. Kapoor, S.S. Kataria, D.M. Nadkarni and V.S. Ramamurthy, "Linear momentum distribution in ^{238}U (α, f) at medium excitation energies, *ibid.*, 34.

R.K. Choudhary, D.C. Biswas, M. Lal and B.K. Nayak, "L-subshell ionisation cross-section with proton of 2·0 to 3·5 MeV", *ibid.*, 126.

D.C. Biswas, P.N. Ramarao, A. Nijasure and R.K. Choudhary, "A hybrid gas ionisation chamber detector telescope for heavy ions", *ibid.*, 136.

M.N. Rao, A. Nijasure, D.C. Biswas and R.K. Choudhary, "^{27}Al (α, p) reaction at sub coulomb energies", *ibid.*, 240.

A. Saxena, R.K. Choudhary, S.S. Kapoor, S.K. Kataria, D.M. Nadkarni and V.S. Ramamurthy, "Fission fragment angular distribution in ^{238}U (α, f) at 40 MeV", *ibid.*, 358.

Suresh Kumar, D.R. Chakrabarty, N.L. Ragoowansi, E.T. Mirgule and M.A. Eswaran, "A charged particle telescope with a gas ionization chamber ΔE detector with axial charge collection", *ibid.*, 140.

S.K. Kataria, Rekha Govil and H.N. Bajpei, "Chemical effects in X-ray fluorescence analysis", Symp. on Recent Trends in Instrumental Methods of Analysis, Roorkee, Feb. 23-25, 1985; 9.

S.K. Kataria, V.S. Ramamurthy, V.G. Gaonkar, S.S. Kapoor and Surendra Kumar, "Personal computer based CAMAC system for data acquisition systems", National Symp. on COMAMRI, Bombay, March 1985.

S.K. Kataria, R. Govil, A. Saxena and H.N. Bajpei, "Chemical effects in X-ray fluorescence analysis', *X-ray Spectrometry* (Jan '86).

S.K. Kataria, Surendra Kumar, V.G. Gaonkar and K.J.S. Sawhney, "Personal computer analyser", National Instrumentation Symposium, Nagpur, Oct 3-6, 1985.

Alok Saxena, R.K. Choudhary, S.S. Kapoor, S.K. Kataria, D.M. Nadkarni and V.S. Ramamurthy, "Linear momentum transfer distribution in ^{238}U (α, f) at medium excitation energies", N.P. Symposium at Jaipur, Dec. 16-20, 985; 34-35.

S.K. Kataria, Aruna Nijasure and V.S. Ramamurthy, "The role of multi-nucleon transfers in nuclear fission and heavy ion reactions", *ibid.*, 80-81.

Alok Saxena, R.K. Choudhary, S.S. Kapoor, S.K. Kataria, D.M. Nadkarni and V.S. Ramamurthy, "Fission fragment angular distribution in ^{238}U (α, f) at 40 MeV", *ibid.*, 368-369.

Ajit Mohanty, V.S. Ramamurthy and S.K. Kataria, "Role of curvature term on critical configuration of fusion", *ibid.*, 370-371.

Alok Saxena, S.K. Kataria, A.K. Mohanty and V.S. Ramamurthy, "PDP 11/23 based multiparameter data acquisition system", *ibid.*, 364-365.

Aruna Nijasure, S.K. Kataria, Ajit Mohanty and V.S. Ramamurthy, "CAMAC and PDP 11/34 based data acquisition system", *ibid.*, 366-367.

J.N. Joshi, Surendra Kumar, V.G. Gaonkar and S.K. Kataria, "Personal computer based time analyser", IPA Seminar on Micro, Mini and Personal Computers in the Laboratory, Jaipur, Dec. 21-23, 1985.

R.P. Anand, H.M. Jain, S. Kailas, S.K. Gupta, V.S. Ramamurthy and S.S. Kapoor, "Neutron capture cross section of Th-232", Int. Conf. on Nuclear Data for Basic & Applied Science, Santa Fe, New Mexico, 1985.

S. Kailas and S.K. Gupta, "Volume integrals of real and imaginary parts of optical potentials for light projectiles", *ibid.*

A.G. Wagh and S.K. Gupta, "The power envelope correspondence between nuclear stopping and interatomic potential", Seventh International Conference on Ion Beam Analysis, Berlin, F.R.G., 7-12 July, 1985.

S.K. Gupta, P.K. Bhattacharya and A.G. Wagh, "Interatomic potentials from nuclear stopping data in semiconductors", 11th International Conference on Atomic Collisions in Solids, Washington D.C. (USA), August 4-9, 1985.

S.K. Gupta, S. Kailas, A. Chatterjee, S. Bhattacharya and S.S. Kerekatte, "Elastic and inelastic scattering of 50 MeV alpha particles from ^{209}Bi", Symp. on Nucl. Phys. **28B** (1985) 18.

S. Kailas, A. Saxena, M.L. Sehgal, P.P. Singh, P. Schwandt, E.J. Stephenson,

D.L. Friesel and Q. Chen, "Study of giant resonances in ^{58}Ni by inelastic scattering of 270 MeV $^{3}He^{+}$ particles", *ibid.*, 64.

H.M. Jain, S. Kailas and S.K. Gupta, "Neutron radiative capture cross-section of Th-232", *ibid.*, 284.

S.S. Kerekatte, C.V.Fernandes and A. Chatterjee, "Carbon stripper foils for the pelletron", *ibid.*, 128.

S.S. Kerekatte and R.V. Patkar, "An improved R.F. ion source", *ibid.*, 338.

S.K. Gupta, "Dynamical rescaling and EMC effect", *ibid.*, 62.

A.B. Santara and B.K. Jain, "The P(^{3}He, t) Δ^{++} reaction", *ibid.*, C27.

N.R. Sharma, B.K. Jain and R. Shyam, "RGM wave function and ^{20}Ne (α, 2 α)^{16}O reaction", *ibid.*, 99.

B.K. Jain, "Excited nucleons in nuclear collisions", Proc. Int. Conf. on Nucl. Physics, World Scientific Publication, Singapore, 1985, 204.

R. Shyam, "D-effects and J-dependence in (α, d) reactions", Nucl. Phys. Symposium, Jaipur, December 16-19, 1985.

R. Shyam, "Pions and hard protons from co-operative effects in intermediate energy heavy ion collision", *ibid.*

Kuldeep and Animesh K. Jain, "Stopping cross-sections of He^{+} ions in the metallic glass Fe82B18", 7th International Conference on Ion Beam Analysis (IBA '85), West Berlin, July 7-12, 1985.

Kuldeep and Animesh K. Jain, "Artefacts in RBS analysis of laser treated surfaces", *ibid.*

M. Lal, R.K. Choudhary, P.N. Rama Rao and D.C. Biswas, "Particle induced X-ray emission (PIXE) - a sensitive method for analytical applications", Seminar by National Society for Instrumentation, Nagpur, Sept. 1985.

M. Lal, R.K. Choudhary, D.C. Biswas and P.N. Rama Rao, "Trace element analysis of normal and cancer bearing animals using proton induced X-ray emission", Seminar on X-ray spectroscopy and related areas, Oct. 27-29, 1985.

S.K. Sharma, Kuldeep and Animesh K. Jain, "Diffusion of gold in metallic glass Fe8OB20", Solid State Physics Symposium, Nagpur, Dec. 27-30, 1985.

S.V. Vidwans, V.P. Salvi, A.A. Rangwala, Animesh K. Jain and B.M. Arora, "Titanium silicide formation by high dose ion implantation in a-Si films", *ibid.*

V.P. Salvi, S.V. Vidwans, A.A. Rangwala, Animesh K. Jain and B.M. Arora, "Silicide formation by high dose vanadium implantation into silicon", *ibid.*

Animesh K. Jain, "Ion beam techniques in the study of diffusion in solids", *ibid.*

Thankam Potti and H.K. Dravid, "Calculation of damage cross-section", *B.A.R.C.-1293.*

M.R. Prasad, N.S. Dixit and V.K. Rohatgi, "Spectroscopic method of temperature measurement in MHD plasmas", National Seminar on Temperature Measurement, New Delhi, 1985.

P. Satyamurthy, N.S. Dixit, M.R. Prasad, N.Venkatramani and V.K. Rohatgi, "Dynamic thermocouple technique to measure high gas stream temperature", *ibid.*

T. Vijayan and V.K. Rohatgi, "Characteristics of exploding wire plasmas", IEEE Trans. on Plasma Science, 1985.

J. Karthikeyan, K.P. Sreekumar and V.K. Rohatgi, "Plasma sprayed thick coatings for high temperature applications", 7th Int. Symp. on plasma chemistry, Eindhoven, 1985.

N.K. Joshi, T.K. Thiagarajan and V.K. Rohatgi, "Radiative heat transfer from combustion plasma", Proc. 3rd National Symp. on Science & Technology, Jaipur, 1985.

V.K. Rohatgi, "Computers for design and control of plasma processes", Workshop on 'Computer-Aided Manufacturing', Univ. of Roorkee, 1986 (Invited talk).

A.S. Paithankar, P. Roycoudhary and V.K. Rohatgi, "Characterisation of a flowing plasma produced by coaxial plasma gun using cylindrical Langmuir probe", Proc. Workshop on Plasma Diagonstics, Centre for Advanced Technology, Indore, 1986.

K.V. Nagesh, S.T. Iyengar, J.A. Gokhale, R.S. Kalghatgi, P.H. Ron and V.K. Rohatgi, "Fast response current, voltage and magnetic field diagnostics", *ibid.*

A.C. Saxena, A.S. Paithankar and V.K. Rohatgi, "Microwave interferometry for electron density measurements in plasmas", *ibid.*

S.N. Sahasrabudhe, P.S.S. Murthy, N. Venkatramani and V.K. Rohatgi, "Laser doppler anemometry (LDA) measurements in a 500 KW MHD Channel", *ibid.*

S.V. Deshmukh, "Electron density measurements by far infrared laser interferometry", *ibid.*

Srinivasan M., Chandramoleshwar K., Pasupathy C.S., Rasheed K.K. and Subba Rao K.K.,"^{233}U fuelled homegeneous reactor Purnima II: Design features and experimental results", Seminar on Fast Reactor Fuel Cycle, IGCAR, Kalpakkam", Feb. 1986.

Subba Rao K., Srinivasan M. and Basu T.K., "Neutronics of Micro-Fission systems and application of Trombay Criticality Formulae (TCF) Part II: burn efficiency in the presence of hydrodynamic expansion", *Atomkern-energie* (1985, in print).

Iyengar P.K. and Subba Rao K., "Perspectives in Neutron Physics Research", *Pramana* **24** (1985) 259.

Srinivasan M., "Feasibility of the application of statistical correlation techniques for the experimental study of the multiplication of 14 MeV neutrons in Be assemblies", *Ann. Nucl. Energy* **12** (1985) 125.

Anil Kumar and Srinivasan M., "Neutron multiplicity equation and its application for (n, 2n) multiplication measurements by statistical corelation techniques", *Nuclear Science and Engineering* (1985).

Sinha Amar, Garg S.B. And Srinivasan M., "Proton and alpha particle induced reaction cross-sections of carbon, cobalt and lead", International nuclear data committee report *INDC (NEA)* **5** (1985).

Sinha Amar, Garg S.B. and Srinivasan M., "Proton and alpha particle induced reaction cross-sections of carbon, cobalt and lead", International nuclear data committee report *INDC (NEA)* **5** (1985).

Sinha Amar, Garg S.B. and Srinivasan M., "Multiplicity distribution of Neutrons in the Spallation of Lead Targets by High Energy Protons", Symposium on Nucl. Phys., Jaipur, Rajasthan, 1985.

Garg S.B. and Sinha Amar, "Generation of ENDF/BIV based 35 group neutron cross section library and its applications in criticality studies", Int. conf. on nuclear data for basic and applied science, Santa Fe, U.S.A., 1985

Garg S.B. and Sinha Amar, "Preequilibrium effects in neutron, proton and alpha emission of niobium", *abid.*

Garg S.B., Srinivasan M. and Subba Rao K.,"Criticality aspects of reactor configurations fuelled with minor actinides", International conference on

emerging nuclear energy systems,Madrid, 1986.

Joneja O.P. and Nargundkar V.R. and Basu T.K., "14 MeV neutron multiplication measurements in lead fusion technology", (accepted for publication).

Sinha Amar, Garg S.B. and Srinivasan M. "Sensitivity studies of neutron multiplicity spectrum in the spallation of lead target", Paper communicated for publication in the *Ann. Nucl. Energy*, **13**(10), (1986) 579. Also the international conference on emerging nuclear energy systems, Madrid, Spain, 1986.

Joneja O.P. and Nargundakar V.R. "Application of multilayered blanket concept to Tokomak configuration and tritium breeding calculations", *Fusion Technology* (Nov. 1985).

Nargundkar V.R., Basu T.K. and Joneja O.P., "Re-analysis of neutron multiplication measurements in thick beryllium and graphite assemblies for 14 MeV neutrons", *Fusion Technology* (1985, in print).

Nargundkar V.R. Joneja O.P., Basu T.K. and Srinivasan M. "Neutronics of a dense Z-Pinch fusion reactor", 4th international conference on emerging nuclear energy system,Spain, 1986

Nargundkar V.R., Srinivasan M. and Joneja O.P., "A comparative study of thermal fusion blanket arrangements", *Fusion Technology* (1986).

Basu T.K., Datta T., Dange S.P. and Srinivasan M., "Experimental study of neutron multiplication in BeO by shift register coincidence technique", *Annals of Nuclear Energy* **13(10),** (1986) 575.

Srinivasan M., "Z-Pinch Research : An Overview", Workshop on Tokamaks, Saha Institute of Nuclear Physics, Calcutta,Jan. 16-18,1985.

Auluck S.K.H., "Axial magnetic field and azimuthally streaming medium energy deuterons in a plasma focus", 4th Int. Workshop on plasma focus and Z-pinch research, Warsaw (Poland), 9-11 September, 1985.

Auluck S.K.H Kulkarni L.V. and Srinivasan M., "Experimental observation of a spontaneous axial magnetic field in a low pressure spark", ibid.

Auluck S.K.H., "A mechanism for Taylor relaxation in Z-Pinches : Part I : dynamo mechanism", *J. Plasma Phys.* (1986, in print).

Auluck S.K.H., "Relaxation of magnetic field in a plasma via the tearing mode", *ibid.*

Sikka S.K., Godwal B.K. and Chidambaram R., "Band theory analysis of shock velocity particle velocity relations for metals", *Bull. Mater.* Sci. 7 (1985) 377.

Chidambaram R., Sikka S.K. and Gupta Satish C., "Phenomenology of the Pokaran PNE experiments", *Pramana* **24** (1985) 245.

Gupta Satish C and Gupta Y.M., "Piezoresistance response of longitudinally and laterally oriented ytterbium foils subjected to impact and quasi-static loading", *J. Appl. Phys.* **57** (1985) 2464.

Gupta Satish C., Sikka S.K. and Chidambaram R., "On orientation relations between a and w phases in Zr by texture studies using neutron diffraction method", *Scripta Metall.* **19** (1985).

Sharma Surindar M. and Sikka S.K., "Lattice dynamical analysis of beta-gamma transformation in Si under pressure", *J. Phys. Chem. Solids* **46** (1985) 477.

Sikka S.K., Godwal B.K. and Vijaykumar V. "Distorted tcc high pressure phase of rare earths in La. 8 Th. 2 alloy at ambient conditions-thop versus modulated hexagonal structure", *Phys. Lett.* **108a** (1985) 83.

Sharma Surindar M., Vijaykumar V., Sikka S.K. and Chidambaram R., "High pressure phase transitions in organic solids 1; alpha-beta transformation in resorcinol", *Pramana J. Phys.* **25** (1985) 75.

Vijaykumar V., Godwal B.K. and Sikka S.K., "Isostructural electronic anomaly in La and La. Th alloys under pressure", *Phys. Rev. B32* (1985) 4212.

Hema Sankaran, Sharma Surindar M and Sikka S.K., "On observation of the volume discontinuity in the insulator to metal transition in CsI in X-ray diffraction experiments", *Phys. Rev. B33* (1986) 3543.

Godwal B.K., Vijaykumar V., Sikka S.K. and Chidambaram R., "Pressure induced AlB$_2$ to MgCu$_2$ type structural transition in ThAl$_2$", Nucl. Phys. & solid state *Phys. Symp. (India)* **28c** (1985)

Godwal B.K., "Lattice phonon effects at high pressures", National seminar on phonon physics, Bhopal ,1985.

Sikka S.K., "Solid-solid high pressure phase transition in elements", Workshop on high pressure techniques, NPL, Delhi, 1985.

Sikka S.K., "Shock Hugoniot equation of state electron band theory approach", APS topical meeting on shock waves in condensed matter, Spokane, Washington State, USA, 1985.

Sikka S.K., "Some systematics of the crystallography of phase transitions in elements under high pressure", XVII National Seminar on Crystallography. Madras, 1985.

Sharma Surinder M., Vijaykumar V. and Sikka S.K., "Phase transition in resorcinol at high pressure", XVI Nat. Seminar Cryst., Delhi, 1985.

Sikka S.K., Godwal B.K., Vijaykumar V. and Vohra Y.K., "Structural aspects of the distorted free high pressure phase of trivalent rare-earth metals and actinides", *ibid.*

Vohra Y.K., Vijaykumar V., Godwal B.K., Sikka S.K. and Chidambaram R., "Some high pressure X-ray diffraction studies using Be gasketing technique on a diffractometer with rotating anode X-ray source." *Rev. Sc. Inst.* **55** (1984) 1593.

Vijaykumar V., Sikka S.K., Godwal B.K. and Chidambaram R., "Isostructural resistivity anomaly in La and La-Th alloys", XAIRAPT conference on High Pressures, Amsterdam, 1985.

Godwal B.K., Sikka S.K., and Chidambaram R., "Electron transfer and equation of state of Ti, Zr and Hf by linear muffin-tin orbital method", Solid State Physics Sym. (DAE), Nagpur, 1985.

Hema Sankaran, Sharma Surindar M. and Sikka S.K., "On the observation of volume discontinuity in insulator to metal transition by X-ray diffraction experiments", *ibid.*

Sharma Surindar M., Vijaykumar V., Sikka S.K. and Chidambaram R., 'High pressure phase transitions in Cd-Hg system", *ibid.*

Godwal B.K. and Vijaykumar V., "High pressure electrical behaviour of Pr and Pr-Th alloys", *ibid.*

Gupta Satish C. and Gupta Y.M., "Response of ytterbium foils oriented parallel and perpendicular to the shock front"

Gupta Satish C. and Gupta Y.M., "Piezo resistance response of manganin foils, experiments and analysis", *Shock Waves in Condensed Matter*, (1985, in print).

Gupta Satish C. and Gupta Y.M., "Effect of matrix properties on the piezo resistance response of ytterbium and manganin foils".

Gupta Satish C., Williams M.R. and Gupta Y.M., "Response of ytterbium foils oriented parallel and perpendicular to the shock front in carbon disulphide matrix", Washington State University, Shock Dynamic Laboratory Report No. *SDL-85-05*, (1985)

Sharma Surindar M., Vijaykumar V., Sikka S.K. and Chidambaram R., "High pressure phase tansitions in organic solids I:a b Transformation in resorcinol," *J. Pramana of Phys.* **25** (1985) 75.

Vijaykumar V., Sharma Surindar M., Sikka S.K. and Chidambaram R., "BCT-HCP transformation in Cd-Hg alloys under high pressure", *J. Phys. F Metal Phys.* (in print).

Sharma Surindar M., Sikka S.K. and Chidambaram R., "A comparative study of the momentum density distribution in phases of Zr by positron annihilation angular correlation measurements", Proc. of 7th Int. Con. on positron annihilation, 1985 (Ed. R.M. Singru and P.C. Jain, World Scientific Pub. Singapore).

Godwal B.K., Sharma Surindar M. and Sikka S.K., "Positron annihilation angular correlation studies on shocked polycrystalline aluminium", *ibid.*

Sharma Surindar M., Vijaykumar V., Sikka S.K. and Chidambaram R., "High pressure phase transitions in organic solids I:a - b transformation in resorcinol", XVI Nat. Seminar Cryst., Delhi, 1985.

Sharma Surindar M., Vijaykumar V., Sikka S.K. and Chidambaram R., "BCT > HCP transformation in Cd - Hg alloys under high pressure", Solid State Physics Symp. (DAE), Nagpur, 1985.

Chakravarty S., Yadava V.S., Vinay Kumar and Kannan K.K., "Drug-protein interaction at molecular level: A study of sulphonamide corbonic anhydrase complexes", (Suppl.) *J. Biosce* **8** (1985) 491-498.

Ramanadham M., Sieker L.C. and Jensen L.H., "Structure of triclinic hen egg-white lysozyme: An X-ray diffraction study at 2A resolution", XVI National Seminar on Crystallography, University of Delhi, Delhi, Jan. 2-4, 1985.

Vinay Kumar, Chakravarty S., Ramanadham M. and Kannan K.K., "Mechanism of inhibition of carbonic anhydrase by anionic inhibitors", *ibid.*

Chakravarty S., Vinay Kumar and Kannan K.K., "Interaction of supjonamide drugs with human carbonic anhydrase", *ibid.*

Yadav V.S. and Kannan K.K., "Role of metal ion cofactors in carbonic anhydrase enzyme", *ibid.*

Kannan K.K., "Macromolecular crystallography", International Winter School on Direct Methods, Macromolecular Crystallography and Crystallographic Statistics, University of Madras and Indian Institute of Technology, Madras, Dec 9-19, 1985.

Ramanadham M., Siekar L.C. and Jensen L.H., "Refinement of protein structures : A case study on triclinic lysozyme", Microsymposium (Dec. 19, 1985) held at the end of the International Winter School on Direct Methods, Macromolecular Crystallography and Crystallographic Statistics, University of Madras and Indian Institute of Technology, Madras, Dec. 9-19, 1985.

Ramanadham M., Sieker L.C. and Jensen L.H., "Solvent structure and hydrogen bonding in triclinic hen egg-white lysozyme", XVII National Seminar on Crystallography, University of Madras and Indian Institute of Technology, Madras, Dec. 20-22, 1985.

Vinay Kumar, Sankaran K. and Kannan K.K., "Crystallization and preliminary X-ray analysis of Indian buffalo erythrocyte carbonic anhydrase", *ibid.*

Vinay Kumar and Kannan K.K., "Inhibition mechanism of carbonic anhydrase by Au(CN)A2 inhibitor", *ibid.*

Vinay Kumar, Sankaran K. and Kannan K.K., "Crystallization and preliminary data of Indian buffalo erythrocyte carbonic anhydrase", *J. Mol. Bio.* (1986 in print).

Ramanadham M., "Crystallography and its applications in biology", Indian Physical Society Workshop on Applications of Physical Techniques in Biology, Variable Energy Cyclotron Centre, Calcutta, Feb. 24-27, 1986.

Yadava V.S. and Kannan K.K., "Role of Metal Ion Cofactors in Carbonic Anhydrases", National Seminar on Crystallography, Delhi 1985.

Yadava V.S., Rose D.R., Phillips D.C. and Sutton B.J., "X-ray Studies on Anti-DNP Antibody combining site", *ibid.*

Chakravarty S., Yadava V.S., Vinay Kumar and Kannan K.K., "Drug protein interaction at the molecular level: A study of sulfonamide carbonic anhydrase complexes ", Proc. Int. Symp. Biomol. Struct. Interaction *B* (1985).

Padmanabhan V.M. and Patel R.P., "Structure of trans dichlorobis (p. fluoro aniline) palladium II", *Acta Crystallographica* **C41** (1985) 1305

Padmanabhan V.M. and Patel R.P., "Structure of Bis (4-hydroxy - L. prolixato palladium (ii) trihydrate", *Acta Crystallography* (1986, in print).

Padmanabhan V.M. and Jakkal V.S., "Crystal Structure cyclic (L-methioxyl-L-prolyl-)", *Acta Crystallographica* 1986 (Submitted for publication).

Padmanabhan V.M., Batra M.K. and Vajpayee V.S., "Uranium ore reserve estimates by geostatistical methods, *Nuclear India* (1986, Communicated for publication).

Padmanabhan V.M. and Rao L.S., "Crystal structure of ortho - chloro - phenoxy acetamide", 17th National Seminar on Crystollagraphy, Madras, 1985.

Padmanabhan V.M. and Patel R.P., "Crystal structure of L-hydroxyprolinato 2-2 bipyridyl palladium (II) chloride digydrate", *ibid.*

Padmanabhan V.M. and Patel R.P., "Crystal structure of dichloro-bis-p. fluoroaxiline Paladium (II)", 16th National Seminar on Crystallography, Delhi , 1985.

Padmanabhan V.M. and Jakkal V.S., "Crystal structure of copper D-alanine", *ibid.*

Padmanabhan V.M. and Sharma R., "Crystal and molecular Structure of pyrrolidizine alkaloids", *ibid.*

Wadhawan V.K., "Ferroelastic Phase Transitions", *Material Science Forum* **3** (1985) 91-110.

Bhagwat K.V., Wadhawan V.K. and Subramanian R., "A New Fourth-Rank Tensor for Describing the Acoustical Activity of Crystals", *J. Phys. C* **19** (1986) 345-357

Wadhawan V.K. and Somayazulu M.S., "Coset-Decomposition Analysis and Optical and X-ray Investigations on Ferroelastic Thallous Nitrate", *Japanese J. Appl. Phys.* (1985, in print).

Bhagwat K.V., Wadhawan V.K. and Subramanian R., "Acoustical Activity and Ferroic Crystals", *ibid.*

Somayazulu M.S. and Wadhawan V.K., "Anamalous Behaviour of Dielectric

Constant in TlNOA3 at 309 K and 329 K", Proc. Solid State Phys. Symp. DAE, *28C*, 1985; 226

Wadhawan V.K. and Somayazulu M.S., "Atomic Mechanism of Ferroelastic Switching and Mechanical Twinning", *Application to Thallous Nitrate Phase Transitions* (1986 , in print).

Wadhawan V.K., "Classification of Twinning in Crystals", XVI National Seminar on Crystallography, University of Delhi, Delhi, January 1985.

Bhagwat K.V., Wadhawan V.K. and Subramanian R., "Acoustical Activity and Ferroic Crystals", Sixth International Meeting on Ferroelectricity, Kobe, Japan, August 1985.

Wadhawan V.K. and Somayazulu M.S., "Coset-Decomposition Analysis and Optical and X-ray Investigations on Ferroelastic Thallous Nitrate", *ibid.*

Somayazulu M.S. and Wadhawan V.K., "Anomalous Behaviour of Dielectric constant in TlNO at 309K and 329K", Solid State Physics Symposium, DAE Nagpur, Dec. 1985.

Bhakay-Tamhane S., Sequeira A and Chidambaram R., "Low-Temperature Phase Transitions in LiKSO : A Neutron Study", *Solid State Comm.* **53** (1985) 197-200.

Bhakay-Tamhane S., Sequeira A and Chidambaram R., "Structure of LiKSO in Low Temperature Phases PII and PIII by Neutron Diffraction", XVI Nat. Seminar on Crystallography, Delhi Univ., Jan., 1985.

Sequeira A., Rajagopal H., Roul B.K. and Choudhary R.N.P., "A High Precision Neutron Study of the Structure of Semi-carbazide. HCl", *ibid.*

Sequeira A., "Neutron Scattering Techniques in the Study of Materials", Proc. National Workshop in Modern Techniques in Materials Research, IIT Kanpur, 1985; 78-90.

Sequeira A., "Neutron Small Angle Scattering Techniques: Its potentialities and Our Plans at Trombay", Seminar on Small Angle Neutron and X-ray Scattering, IGCAR, Kalpakkam, 1985.

Rao K.R. and Sequeira A., "Neutron Beam Research in India", *Neutron Diffraction Newsletter* of the Int. Union of Cryst. (April 1985).

Desa J. A. E., Mazumdar S., Sequeira A and Dasannacharya B. A., "A Small Angle Neutron Scattering Facility at the CIRUS Reactor", Proc. Solid State Phys. Symp. **28C** (1985).

Rajagopal H., Sequeira A., Roul B.K. and Choudhary R.N.P., "A Single Crystal Neutron Diffraction Study of the Structure of Deuterated Semicarbazide. HCl", XVII Nat. Seminar on Crystallography, Univ. of Madras, Dec., 1985.

Bhakay-Tamhane S., Sequeira A. and Chidambaram R., "Refinement of Twinned Crystal Data", *ibid*

Bhakay-Tamhane S. and Sequeira A., "Kinetics of Low Temperature Phase Transitions in LiKSO", *Ferroelectrics* (1986, in print)

Bhakay-Tamhane S., Karunakaran C. and Vaidya S.N., "Critical point in the phase diagram of LiKSO", *High Temperatures - High Pressures* (1986, in print).

Mukhopadhyay R., Bhakay-Tamhane S. and Paranjpe S.K., "Powder Neutron Diffraction Study of L.T. Phase Transition in LiKSO", *Solid State Comm.* (1986, in print).

Chidambaram R (ed.), *Neutron Diffraction Newsletter* of the Int. Union of Cryst. (April, 1985).

Mazumdar S., "Small Angle Neutron Scattering from Solutions by G. Zaccai", Internal Report on Lecture notes compiled by S. Mazumdar (1985).

Bhakay-Tamhane S., "Structural Investigation of Low Temp. Phase Transitions in LiKSO and (NH) CuCl ·2H O", Solid State Phys. Symp., Nagpur, Dec., 1985.

Bhakay-Tamhane S., "Structural Investigations of L.T. Phase Transitions in (NH) $CuCl{\cdot}2H_2O$ and LiKSO, Univ. of Bombay, 1985.

2. CHEMICAL SCIENCES

2·1 Basic Chemistry

Progress was maintained in the thrust areas of radiation and photochemistry, laser chemistry, reaction dynamics, isotope effects, interfacial phenomena, and structural chemistry. A few sophisticated instruments and facilities needed for advanced research in these areas, such as nanosecond time domain fluorescence spectrometer, TEA IR laser, a quadrupole mass analyser, and a high current nanosecond pulsed electron accelerator are under various stages of installation and commissioning. The molecular beam chemiluminescent equipment built at Trombay started providing information on dynamics of chemical reactions in short time scales.

Infrared laser induced pumping of vibrational levels of perfluoropyridine molecule and its light emission in the visible region was shown for the first time, thereby indicating energy transfer to electronic levels of the molecule which has considerable theoretical and practical implications.

Theoretical model proposed earlier for valence and magnetic transitions in mixed valence solids was successfully used to explain experimental results. A two phase cluster model proposed earlier for one component inorganic glasses and their melts was found to be consistent with the observed trends in their physical properties. A new theoretical approach of general applicability for studying metal complexes by ion exchange techniques was developed. Viscoelastic behaviour of hydroxy benzoic acids in micellar systems was satisfactorily explained on the basis of NMR studies.

Experimental evidence was obtained for the incorporation of aliphatic hydrocarbon solvent molecules in the polymer chain produced by gamma radiation induced polymerisation of methylmethacrylate. New research and development programmes initiated include synthesis and investigation on magnetic and super-conducting properties of a series of substituted molybdenum chalcogenides, theoretical and experimental efforts to understand structured fluids, and molecular beam chemiluminescent studies in the interaction of metal vapours with organic and inorganic small molecules.

Considerable expertise has been developed in computer plotting of complex molecules with a stereo view.

2·2 Water Chemistry

The facilities in the newly established Water and Steam Chemistry Laboratory at Kalpakkam are being augmented to cater to the requirements of our programme. A mini computer, installed recently, is being used to simulate the chloride build up in MAPP-I secondary system as a function of time and condenser tube leakage. The software package works as an early warning device to initiate corrective action in the event a sea water ieak occurs. Some of the other important aspects of direct relevance to FBTR and MAPP that are being currently pursued are physico chemical features of coastal waters, marine biofouling at the intake jetty, water quality survey in open reservoir, crud characterization and activity monitoring of the PHT system of MAPS-I. Components for a high temperature-high pressure loop for model steam generator studies are being assembled.

As part of a back-up for the design of 500 MWe PHWRs, normal and peak purification flow rates for PHT system were computed and the performance of nuclear grade indigenous ion exchange resins for PHT system were evaluated for osmotic shock resistance, as well as for mixed bed performance. The R & D efforts also include studies on cooling water chemistry in heavy water plants. Improved chemical processes were developed for plugging of micro holes in pipes in inaccessible locations of nuclear installations.

A chemical method to remove the Al turbidity from the heavy water used initially in DHRUVA was developed and applied to the reactor system. The reactor turbidity was first identified by electrophoretic and X-ray powder diffraction techniques to be Bayerite aging to Gibbsite (both are different modifications of Al_2O_3. $3D_2O$). Initially a powdex strong cation exchanger in H^+ form was studied which cleared $2{\cdot}5 \times 10^3$ ppm bed volumes of turbidity. Replacing the H^+ by Mg^{++} ion helped in realising $4{\cdot}25 \times 10^3$ ppm bed volumes. The choice of Mg was made because of its high charge/radius ratio as

compared to other ions. By switching over to a powdex weak acid resin in Mg^{++} form, because of its higher capacity, the ppm bed volumes realisable become more than 1.4×10^4. Incorporation of $Mg(OH)_2$ in this weak acid resin matrix to give $(RCOO)_2Mg{\cdot}Mg(OH)_2$ resulted in an order of magnitude improvement in turbidity clearance, the value obtained being $4{\cdot}2 \times 10^5$ ppm bed volumes. Experiment conducted with Dhruva D_2O on this resin has revealed that this bed,while removing the Al turbidity, had also removed the activity associated with it.

The first charge of this resin was responsible in reducing the reactor heavy water turbidity from 136 ppm to 36 ppm, Uranium from 100 ppb to 36 ppb and system β γ activity from 6000 pCi/ml to 2000 pCi/ml. The second charge of the resin brought down the turbidity to less than 2 ppm, U to < 10 ppb and system β, γ activity to 600 pCi/ml. The operation of a centrifuge in parallel with this second charge of Mg bed partly quickened the cleaning-up process.

2·3 Fuel Chemistry

Thermochemical studies on FBTR fuel and clad were continued to assess the fuel-clad compatibility. These included the study of carbon potential of fuel and the clad as a function of temperature (Fig. 1). Carbon-monoxide pressure in equilibrium with the fuel at high temperatures was also measured to assess the transport of carbon from the central high temperature region of the fuel to the clad. Direct solid-solid reaction between the fuel and the clad was studied in the temperature range of 1220 to 1660 K.

Thermodynamic studies of a number of systems relevant to understanding of fuel and fission products reactions in an operating fuel were carried out. One of the spin offs of this work is the design and fabrication of a high temperature Knudsen cell for vapour pressure measurements on refractory materials at high temperatures. Oxygen potential of mixed uranium-thorium oxide fuel containing 10-20% thorium was measured using a solid state galvanic cell. Thermodynamic parameters of fission product compounds of caesium were obtained using solution calorimeter and a high temperature calorimeter. Chemical, thermal and X-ray methods were used for characterisation of newly synthesised uranates (Table 1) as well as for solid state reactions of plutonium oxide, uranium oxide and thorium oxide with ammonium sulphate at a temperature of 280°C

Phase equilibrium and phase transition studies on certain ceramic compounds such as molybdates, tungstates, uranates and perovskites were investigated and the energetics as well as structural aspects were determined. Kinetics of the fission gas release from irradiated fuels was investigated.

Thermal ionisation mass spectrometry and alpha spectrometric studies were carried out with a view to simplifying the procedures for determining plutonium concentration in dissolver solution of irradiated fuel (Tables 2 & 3 and Fig. 2).

Inductively coupled argon plasma atomic emission spectrometric method was standardised for the determination of lanthanides after their chemical separation in uranium-aluminium alloy samples. The analytical performance characteristics are given in Table 4. Atomic absorption spectrometric studies of the atomisation processes of boron in carbon rod atomiser showed that atomisation efficiency improves considerably in the presence of ascorbic acid and titanium indicating their possible use as efficient matrix modifiers. This is illustrated in Fig. 3. Spark source mass spectrometrically determined relative sensitivity factors for different lanthanides were correlated to their physico-chemical properties which are useful for determining lanthanides in various fuel matrices without requiring the trace constituent standards (Table 5 and Fig. 4).

An engineering scale semi-continuous facility was set up and successfully operated for the preparation of 500 g per day uranium oxide microspheres by sol-gel process (see photograph).

2·4 Radiochemistry

The programme of work centred around nuclear and physico-chemical studies on actinides and fission products. Radiochemical studies have been carried out on charge distribution and fragment angular momenta in the neutron induced fission of U-233, U-235, Np-237, Pu-239 and Pu-241. It is observed that the angular momenta of odd-Z fragments are high compared to their neighbouring even-Z ones. This was attributed to polarization of even-Z core by the odd proton (Fig. 5). A systematic decrease in the angular momentum of the fragments as a function of neutron number of the complementary fragments brings out the importance of 66 neutron deformation (Fig. 6). Alpha particle induced fission of Th-232 and U-238 was studied to arrive at important information about the role of excitation energy and saddle properties on the fission process. The results obtained in the mass distribution and mass resolved angular distribution in the alpha particle induced fission of Th-232 are given in Fig. 7 and Table 6 respectively. A new and simple method of correction for self-multiplication of neutrons in samples containing large amounts of plutonium was evolved leading to accurate estimates of plutonium in sealed containers by the neutron coincidence counting technique (Fig. 8). Half-life of Pu-241 was determined precisely and accurately by two independent methods and this work has resolved the discrepancy in the values reported earlier in literature (Fig. 9).

Studies were carried out on the synergistic extraction of curium from aqueous thiocyanate medium and from non-complexing perchlorate medium. Equilibrium constants were also determined for the various species in these studies. Investigations carried out on the synergistic extraction behaviour of uranium showed that stearic hindrance plays a part in the complexation of uranyl ion with PMBP and sulphoxides containing more than 7-8 carbon chain length (Fig 10). Electron paramagnetic resonance studies were carried out on gamma irradiated ammonium uranyl phosphate. The spectra of radicals formed (PO_4^{-2} and NH_3^{+}) and their temperature dependence are shown in Fig. 11.

2·5 Analytical Chemistry

Development and validation of analytical methodologies for the R & D programmes of BARC and other constituent units of DAE was continued and this constituted a very major part of the analytical chemistry effort. The important analytical chemistry work done during this year includes determination of gases in samples of stainless steel from DHRUVA and TAPS, zircaloy from NFC, iron and vanadium alloys and superconducting niobium-titanium alloys. A number of special analytical services were provided to several institutions outside DAE. These include analysis of amzirc (a high conducting high endurance alloy developed in BARC for use in HAL, Hyderabad), copper contact wire from Ministry of Railways, gold in sea sedimens for Customs, lead in blood samples from workers of spray paint shop of Air India, iron, chromium, nickel, aluminum and titanium in engine oils of Air Bus and cadmium in cartridge brass samples from Ordinance Factory, Ambernath. Analytical service was also rendered for MIC residue analysis after the Bhopal gas leakage.

Existing facilities for instrumental analysis have been augmented by installation of a special spectrometer provided with a dynamic background corrector to be used for a quality assurance programme of analyses jointly with five National laboratories under a collaborative programme of the Department of Environment. An intercomparison work has been completed and the results have been communicated to the concerned laboratories. A workshop on Quality Assurance of Analytical Data was also organised in BARC as part of ar integrated programme of the Department of Environment on heavy metals.

Table 1

CRYSTAL PARAMETERS OF NEW URANATES

Compound	Crystal System	Cell Parameters	Density g/ml	No. of molecules
$Rb_2U_4O_{12}$	Rhombohedral	a–9·246A°; –94·8°	5·48	2
$K_2U_4O_{12}$	Tetragonal	a–7·95A°; c–10·69A°	6·2	2
$Tl_2U_4O_{12}$	Rhombohedral	a–8·195A°; –92·6°	13·96	3

Table 2

Results of plutonium concentration in different plutonium samples using ^{239}Pu, ^{240}Pu and ^{242}Pu spikes in isotope dilution thermal ionisation mass spectrometry (ID – TIMS)

Plutonium concentration (μg/g)			(I)	(II)
ID–TIMS (^{239}Pu) (I)	ID–TIMS (^{240}Pu) (II)	ID–TIMS (^{242}Pu) (III)	(III)	(III)
8·466	8·507	8·489	0·9973	1·0021
3·960	3·964	3·964	0·9990	1·0000
6·461	6·471	6·452	1·0014	1·0029
23·110	23·188	23·187	0·9997	1·0000
7·863	7·870	7·880	0·9978	0·9987
7·124	7·122	7·139	0·9979	0·9976
35·916	35·882	35·860	1·0016	1·0006
14·788	14·777	14·801	0·9991	0·9984
22·346	22·336	22·342	1·0002	0·9997
Mean			0·9990	1·0000

Mean relative precision : 0·1 to 0·2%

Table 3

Concentration of plutonium in various samples as determined by isotope dilution alpha spectrometry (IDAS) and isotope dilution mass spectrometry (IDMS)

Concentration of plutonium (μg/g)			(I)	(I)
IDAS – 1	IDAS – 2	DMS (^{242} Pu)	(III)	(III)
76·20	76·27	75·92	0·9991	1·0037
67·75	67·60	67·11	1·0022	1·0095
84·98	85·80	85·19	0·9904	0·9975
77·23	77·53	77·15	0·9961	1·0010
84·71	84·85	83·98	0·9983	1·0087
148·24	148·34	147·64	0·9993	1·0041
138·38	138·58	138·21	0·9985	1·0012
113·51	114·35	113·58	0·9926	0·9994
Mean			0·9997	1·003

IDAS–1 : Samples without purification

IDAS–2 : Samples with purification

Mean relative precision : 0·2 to 0·3%

Table 4

Analytical Performance Characteristics for Rare Earth Elements in (U. Al) Alloy by ICP–AES

Element	Estimation Range μg/ ml	Amount Added ppm	Amount Found ppm	% RSD*
Dy	0·02–10	0·5	0·49	2
Eu	0·02–10	0·5	0·50	3
Gd	0·05–10	0·5	0·62	13
Sm	0·10–10	0·5	0·52	10
Dy	0·02–10	2	1·85	0·5
Eu	0·02–10	2	1·77	0·5
Gd	0·05–10	2	1·87	1
Sm	0·1–10	2	1·90	1

*Based on 12 replicate measurements

Lines 85. (230)

Table 5

Experimental and computed relative sensitivity factors (RSF) for lanthanides in U_3O_8 matrix using Er as internal standard.

Computed values based on dissociation energies of sesquioxides (RSF–1) and dissociation energies of monoxides (RSF–2)

Element	Experimental RSF value	Computed RSF values	
		RSF –1	RSF –2
Ce	0·99	0·92	0·80
Nd	1·12	1·04	0·87
Sm	1·23	1·14	1·07
Eu	1·26	1·27	1·10
Gd	0·91	0·97	0·85
Dy	1·06	1·03	1·00
Er	1·00	1·00	1·00
Lu	0·88	0·92	0·85

Table 6

Observed Anisoteopies of the Fission Products

Fission Products	^{97}Zr	^{99}Me	^{132}To	^{143}Ce	^{112}Pd	^{117m}Cd
W(O)w(90)	1·76	1·72	1·70	1·80	1·38	1·42
Average		1·75 ± 0·005			1·40 ± 0·02	
$K_G{}^2h^{21}$		35 ± 2			65 ± 3	

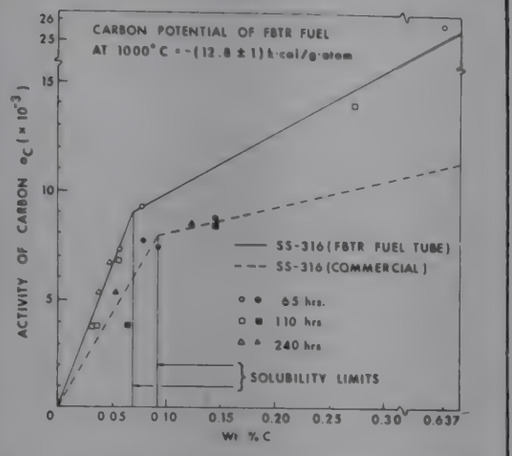


FIG.-1. C-ACTIVITY OF S.S. AS A FUNCTION OF C-CONTENT AT 1000°C TEMPERATURE

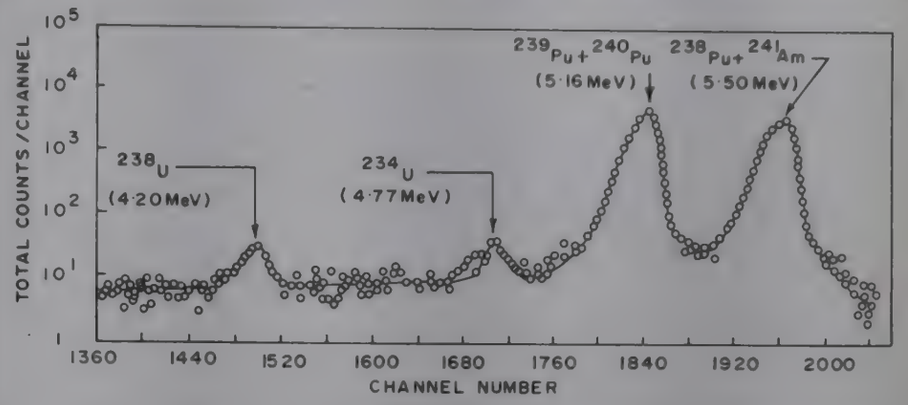


FIG.-2. TYPICAL ALPHA SPECTRUM FROM DROP DEPOSITED SOURCE BY USING TEG ON ELECTROPOLISHED S.S. DISK (UNPURIFIED DISSOLVER SOLUTION SPIKED WITH ^{238}Pu)

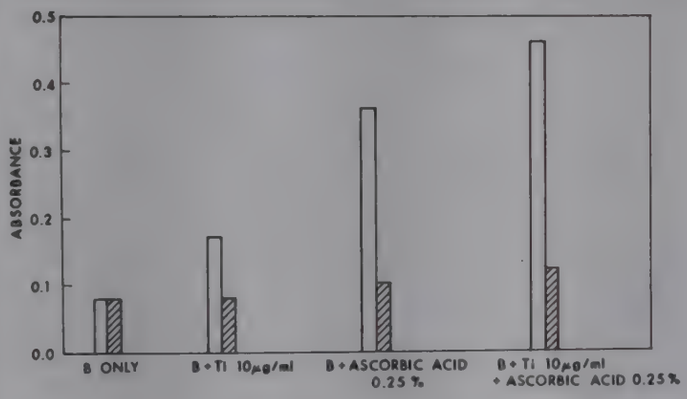


FIG.-3 THE EFFECT OF Ti AND ASCORBIC ACID ON THE FORMATION OF BORON IN CARBON ROD ATOMIZER. THE SHADED PORTION SHOWS NON SPECIFIC ABSORBANCE.

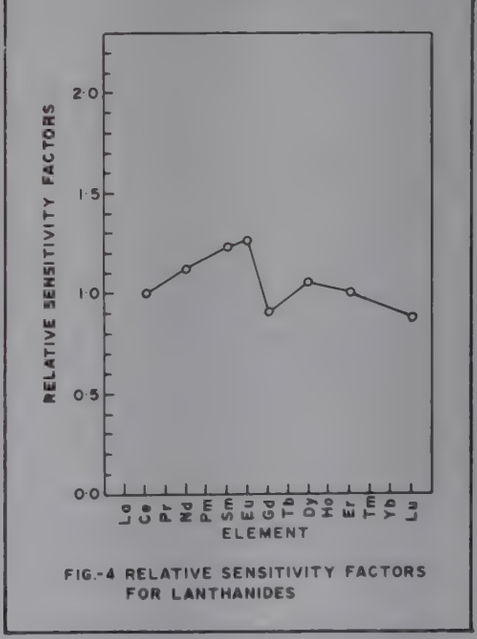


FIG.-4 RELATIVE SENSITIVITY FACTORS FOR LANTHANIDES

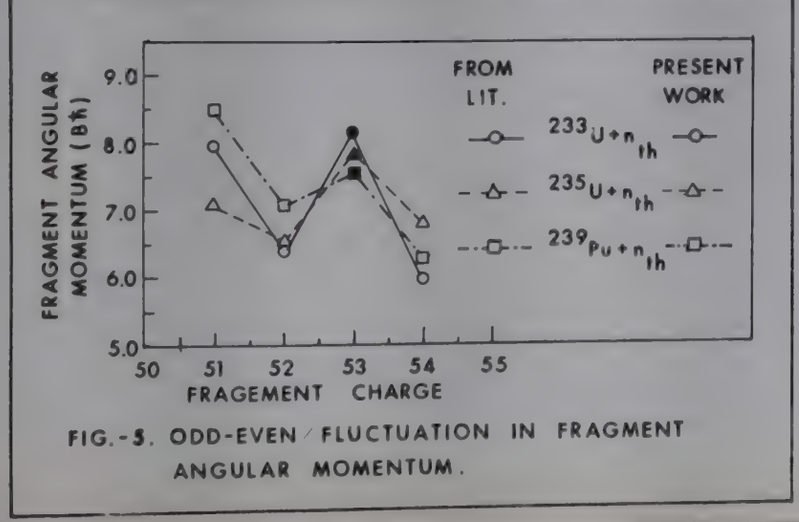


FIG.-5. ODD-EVEN FLUCTUATION IN FRAGMENT ANGULAR MOMENTUM.

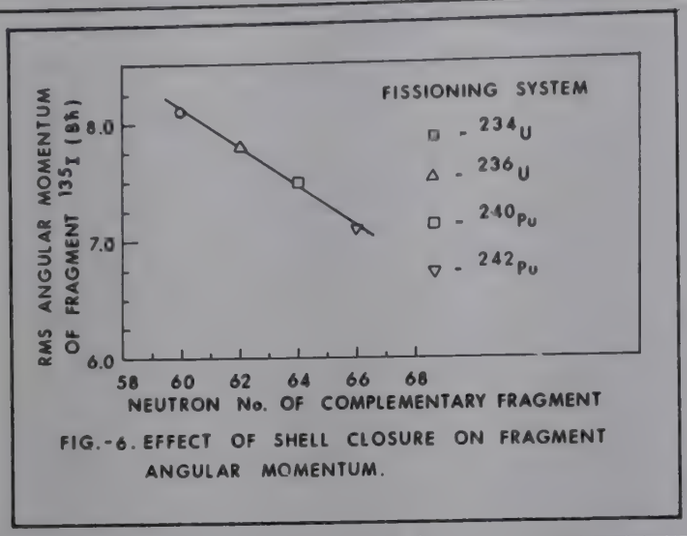


FIG.-6. EFFECT OF SHELL CLOSURE ON FRAGMENT ANGULAR MOMENTUM.

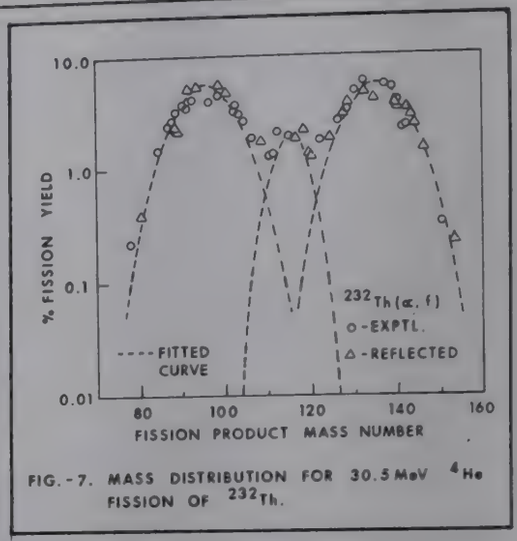


FIG.-7. MASS DISTRIBUTION FOR 30.5 MeV ^{4}He FISSION OF ^{232}Th.

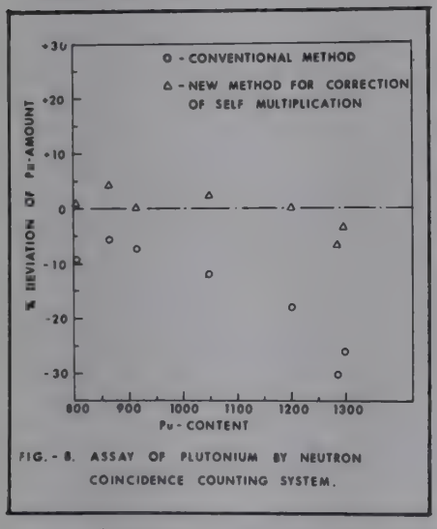


FIG.-8. ASSAY OF PLUTONIUM BY NEUTRON COINCIDENCE COUNTING SYSTEM.

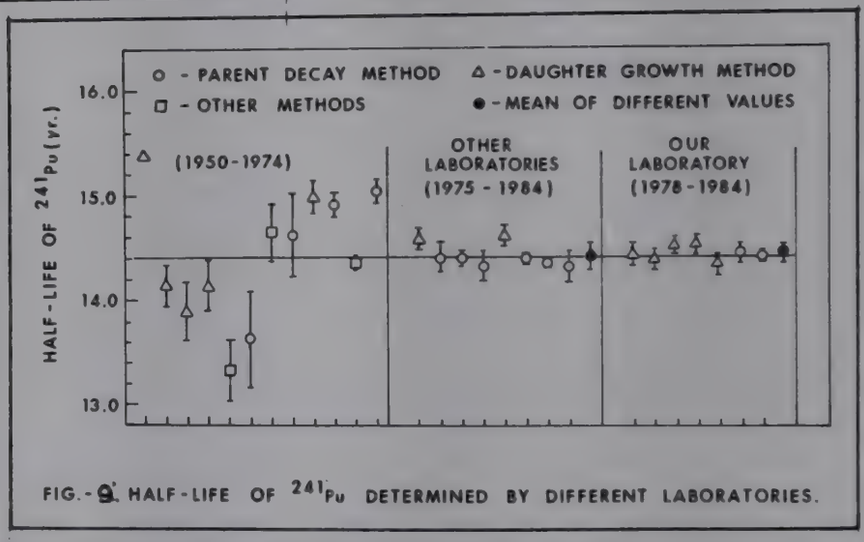


FIG.-9. HALF-LIFE OF ^{241}Pu DETERMINED BY DIFFERENT LABORATORIES.

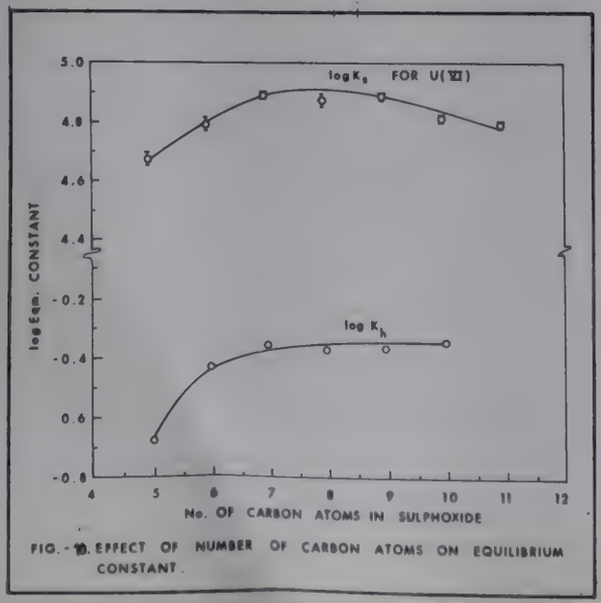


FIG.-10. EFFECT OF NUMBER OF CARBON ATOMS ON EQUILIBRIUM CONSTANT.

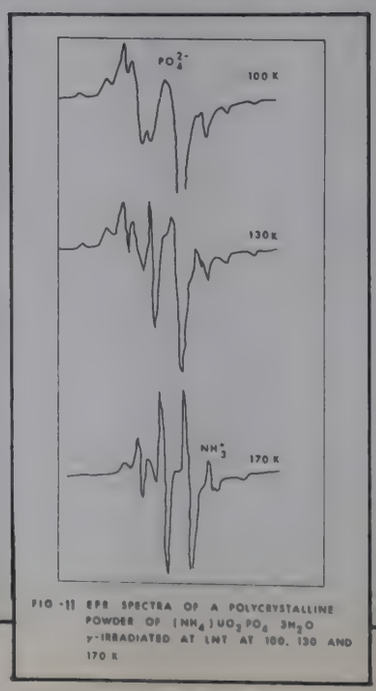


FIG.-11 EPR SPECTRA OF A POLYCRYSTALLINE POWDER OF $(NH_4)UO_2PO_4 \cdot 3H_2O$ γ-IRRADIATED AT LNT AT 100, 130 AND 170 K

Publications

J.P. Sukla, P.M. Ravi and M.S. Subramaniam, "Thermodynamic proton-ligand stability constants of tropolane in mixtures of water and dioxane", *Thermochimica Acta 89* (1985) 271-280.

J.P. Sukla, P.M. Ravi, M.S. Subramaniam, "Potentiometric studies on the complex formation between hexavalent uranium and tropolane", *ibid.* (in print).

Savita Jain, S.K. Samanta, S.S. Raj, M. Ramaswamy and R.C. Rastogi, "Studies on Pd./charcoal catalysts for isotopic exchange reaction in H_2/H_20 medium", 7th National Symposium on Catalysis, Baroda, Feb. 6-8, 1985.

G.R. Relan, A.R. Joshi and R.H. Iyer, "Redox determination of U in presence of Pu in low phosphoric acid medium and the recovery of Pu: some new observations", *J. Radioanalytical and Nuclear Chemistry* **89**(*2*) (1985) 379-388.

A.K. Pandey, R.C. Sharma and R.H. Iyer, "Potentiometric determination of U in phosphate-perchlorate medium and its applicability in the Natural Uranium Fuel Cycle", *ibid.* **99**(*2*) (1986).

R.H. Iyer, "Solid state nuclear track detectors (SSNTDs) - a versatile experimental tool for research in basic and applied sciences", Bulletin, Indian Association of Nuclear and Allied Scientists, Dec., 1985.

A.U. Bhanu and R.H. Iyer, "Measurement of fission to alpha branching ratios of heavy element isotopes using CR-39 plastic track detector", Fourth National Seminar-cum-Workshop on SSNTDs : Application to earth sciences, Dehradun, Nov. 4-6, 1985.

P.C. Kalsi, A.U. Bhanu, S. Sahoo, R.H. Iyer, "Application of the track-etch technique to the analysis of scrap and waste generated at the various stages of the Nuclear Fuel Cycle", *ibid.*

P.C. Kalsi, A.U. Bhanu, S. Sahoo, R.H. Iyer and V.K. Warty, "Recovery of U from the fused salt cake generated at the natural uranium metal fuel fabrication plants", Proc. DAE Symp. on Radiochemistry and Radiation Chemistry, Paper No. CT-2, IIT, Kanpur, Dec. 9-13, 1985; 394.

P.C. Kalsi, A.U. Bhanu, S. Sahoo and R.H. Iyer, "Estimation of U in scrap and waste generated at the various stages of the nuclear fuel cycle using the technique of track registration from solution medium Part I", Report No. *NUMAC/TECH/R & D/CONF/85-17.*

M.B. Yadav and Hari Singh, "Experimental design and analysis of data for the determination of Bias in potentiometry and coulometry methods using NBS 950 a U_3O_8 and assigning a value for the uranium content of NUMAC U_3O_8 material — a study; Report No. NUMAC/TECH/R&D/GEN/85–18.

M.B. Jadav and Hari Singh, "Lecture notes on design of experiments", Report No. NUMAC/TECH/R&D/GEN/85-19.

V. Ramshesh, "Recoil chemistry and solid state exchange in cobalt complexes", *Ind. J. Chem* **24A** (1985) 91.

M.J. Collins, U.R.K. Rao and G.J. Schrobilgen, "^{75}As NMR study of $As[OTeF_5]_6^-$ in solution", *J. Magnetic Resonance* **61** (1985) 137.

A.V. Salker, E.B. Mirza, V.V. Deshpande and H.V. Keer, "Thermodynamic analysis of the phase transition in V_4O_7", *Phys. Stat. Solidi A* **84** (1985) K 105.

D. Das, S.R. Dharwadkar and M.S. Chandasekharaiah, "Thermodynamics of vapourisation of liquid uranium", *J. Nucl. Materials* **130** (1985) 217.

S.N. Tripathi, G. Chattopadhyay, A.S. Kerkar and M.S. Chandrasekharaiah, "Thermodynamic stability of $UMoO_6$ by transpiration technique", *J. Amer. Cer. Soc.* **68** (1985) 232.

U.R.K. Rao, K.S. Venkateswarlu and B.N. Wani, "On the preparation and thermal stability of $[NH_4]_3$ VOF_6 1·5 H_2O and $[NH_4]_3NbOF_6$ 1·5 H_2O", *J. Fluorine Chemistry* (in print).

U.R.K. Rao, K.S. Venkateswarlu and B.N. Wani, "Phase transition in ammonium oxyfluorevanadates", *Thermo-Chemica Acta* (in print).

K.S. Venkateswarlu, "From raw water to pure steam: problems in thermal power stations", *Corrosion and Maintenance* **VIII** (*3*),(July-Sept. 1985), 187-192.

K.S. Venkateswarlu and P.K. Mathur, "Water in thermal power stations", *Science Reporter,* (Oct. 1985) 346-351.

Z.H. Abbas and K.S. Venkateswarlu, "Mechanistic studies in the recoil chemistry Cis-dichloro triethylene tetramino Co(III) chloride", Int. Symp. on Artificial Radioactivity, Pune, 1985.

D. Das, S.R. Dhawadkar and M.S. Chandrasekharaiah, "High temperature phase diagram of Ta-U, W-U and Re-U binaries above 2000°K", 9th Symp. on Thermophysical Properties, Boulder, Colarado, USA, 1985

Chintamani Das and G. Venkateswaran, "Studies on the formation of protective sulphide coatings on carbon steel surfaces", International Conference on Corrosion Science and Technology, Calcutta, 1985.

K.S. Venkateswarlu and A.K. Sriraman, "Sea water quality demands relevant to power generation and reactors", Seminar on seawater quality demands, Bombay, Feb. 20-21, 1985.

A.K. Sriraman and K.S. Venkateswarlu, "Improved techniques and methods for monitoring seawater parameters", *ibid.*

K.V.K. Nair, "Impact of a nuclear power plant on the hydrological characteristics of Kalpakkam coastal waters", *ibid.*

A.C. Momin, E.B. Mirza and M.D. Mathews, "Low temperature behaviour of the perovskites $LaCrO_3$, $LaMnO_3$, $LaFeO_3$ and $LaAlO_3$", IVth Conference of I.C.C. Gorakhpur, December 29, 1984 to January 2, 1985.

A.C. Momin, E.B. Mirza and M.D. Mathews, "Thermal studies of $LaCoC_3$", *ibid.*

K.S. Venkateswarlu and G. Venkateswaran, "Evaluation and improvements in the performance of zircaloy clading after its residence in water cooled power reactors", Technical Committee Meeting on External Cladding Corrosion in Water Power Reactors organised by IAEA at CENCADARSCHE France, Oct. 14-18, 1985.

P.K. Mathur, "Recent advances in water chemistry control of nuclear power plants", 22nd Annual Convention of Chemists, Raipur, Nov. 4-8, 1985 (Pub. in Abstracts).

S.R. Dharwadkar, G. Chattopadhyay, S.N. Tripathi, M.C. Naik, A.R. Paul, K.N.G. Kaimal, M.S. Chandrasekharaiah and K.S. Venkateswarlu, "Basic thermodynamic and transport properties of some fission products in oxides and intermetallic systems relevant to the behaviour of nuclear fuel", Technical Committee on Internal Fuel Rod Chemistry and Fission Products Behaviour held at KFK, Karlsruhe, FRG, Nov. 11-15, 1985.

V.S. Jakkal, V. Amirthalingam and V.M. Padmanabhan, "X-ray crystal structure determination of copper d, l alanine monohydrate", XVIth National Seminar on Crystallography, Delhi, Jan. 2-4, 1985.

A.B. Phadnis, V.V. Deshpande and K.S. Venkateswarlu, "Influence of compaction pressure and porosity on the solid state formation of a compound: a case of $La_2(MoO_4)_3$, Vth National Symposium on Thermal Analysis, IIT, Kharagpur, December 20-22, 1985.

S.R. Dharwadkar, "Standard free energy of formation of $UMoO_6$ by thermogravimetric technique", *ibid.*

M.D. Mathews, E.B. Mirza and A.C. Momin, "DSC studies of rare-earth perovskites $NdCrO_3$, Nd Mo O_3, $NdFeO_3$ and $NdCoO_3$", *ibid.*

M.D. Mathews and A.C. Momin, "Thermal expansion and characterisation of doped UO_2, ThO_2 and (U, Th) O_2", *ibid.*

C.G.S. Pillai, M.D. Mathews and A.C. Momin, "Thermal studies of strontium uranates", *ibid.*

G. Chattopadhyay and P.N. Namboodiri, "On the existence of basic tellurium nitrate", *ibid.*

A.S. Kerkar and M.S. Chandrasekharaiah, "Design and fabrication of an electron bombarded Knudsen effusion cell apparatus", *ibid.*

K.S. Venkateswarlu, "Inputs on water and steam chemistry in the design of 500 MWe PHWRs", Proc. Symp. on Construction and Commissioning of Nuclear Power Plants and their Associated Systems, Bombay, Feb. 25-27, 1985; 208-210.

P.K. Mathur, K.S. Venkateswarlu, A.P. Deshpande and P. Jagadisan, "R and D approach for an evaluation of steam generator tube performance vis a vis normal and off normal water chemistry conditions", *ibid.*, 211-213.

A.M. George, M.A. Vaidya, A.B. Phadnis and V.V. Deshpande, "Reactions of hydrated zirconia with calcium oxide, carbonate and oxalate", Vth National Symposium on Thermal Analysis, IIT Kharagpur, Dec. 20-22, 1985.

K.D. Singh Mudher, A. Chadha, K. Krishnan, N.C. Jayadevan and V.V. Deshpande, "Solid state reactors of ammonium sulphate and ammonium bisulphate with uranium dioxide", *ibid.*

P.S. Parvathanathan, E.B. Mirza, Geeta Datta and K. Usha Deniz, "Calorimetric investigation of bound water in model membranes and in lysozyme solutions", *ibid.*

P.S. Parvathanathan, E.B. Mirza, Geeta Datta and K. Usha Deniz, "Structural water in lyotropics (model mebrances) and protein solutions" Solid State Physics Symposium, Nagpur, Dec. 1985.

P.K. Mathur and A.S. Gokhale, "Development of a suitable cleaning formulation and actual chemical cleaning operations of uranium melting furnance top covers in Atomic Fuels Division", *B.A.R.C./I-828* (1985).

R.M. Sawant, G.H. Rizvi, N.K. Chaudhuri and S.K. Patil, "Determination of stability constatnts of Np(V) fluoride complex using a fluoride ion selective electrode", *J. Radioanal. and Nucl. Chem.* **89** (1985) 373.

R.M. Sawant, N.K. Chaudhari, G.H. Rizvi and S.K. Patil, "Studies on the fluoride complexing of hexavalent actinides using fluoride ion selective electrode", *ibid*, **91** (1985) 41.

R.K. Rastogi, N.K. Chaudhari, G.H. Rizvi and M.S. Subramanian, "On the use of hydrogen peroxide as masking agent for the determination of yttrium in uranium oxide-yttrium oxide mixture", *ibid.*, Lett. **96** (1985) 489.

G. Chourasiya, R.K. Duggal, C.P. Singh, A.S. Rawat, S.K. Aggarwal and H.C. Jain, "Determination of alpha activity ratios by alpha spectrometry in the presence of large amounts of uranium", *ibid.* Articles **89** (*1*) (1985) 89.

S.K. Aggarwal, G. Chourasiya, C.P. Singh, A.S. Rawat, S.A. Chitambar and H.C. Jain, "Determination of plutonium concentration by isotope dilution mass spectrometry using ^{239}Pu as a spike ", *ibid.*, Letters **93** (*3*) (1985) 141.

B.P. Datta, V.A. Raman, V.L. Sant, P.A. Ramasubramanian, P.M. Shah, K.L. Ramakumar, V.D. Kavimandan, S.K. Aggarwal and H.C. Jain, "An experimental evaluation of procedures used for quantitative analysis in RF- spark source mass spectrometry", *Int. J. Mass Spectrom. Ion Processes* **64** (1985) 139.

S.K. Aggarwal, A.R. Parab, S.A. Chitambar and H.C. Jain, "Half-life of ^{241}Pu", *Phys. Rev.* **C31**(*5*) (1985) 1885.

K.L. Ramakumar, A.R. Parab, P.S. Khodade, A.I. Almaula, S.A. Chitambar and H.C. Jain, "Determination of isotopic composition of boron", *J. Radioanal. Nucl. Chem.* Letters **94**(*1*) (1985) 53.

K.L. Ramakumar, S.K. Aggarwal, V.D. Kavimandan, P.M. Shah, V.A. Raman and H.C. Jain, "Relative sensitivity factors for the rare earth elements in different materials employing spark source mass spectrometry", *Spectroscopy* Letters **18** (*7*) (1985) 511.

S.K. Aggarwal, G. Chourasiya, R.K. Duggal, C.P. Singh, A.S. Rawat and H.C. Jain, "A comparative study of different methods of preparation of sources for alpha spectrometry of plutonium", *Nucl. Instrum. Methods Phys. Res.* **A238** (1985) 463.

S. Sampat, N.K. Kulkarni and Chackraburtty, "Influence of selected metal oxides on the oxidation kinetics of graphite", *Thermochimica Acta* **86** (1985) 7.

A.G. Godbole, Rajendra Swarup, and S.K. Patil, "Studies on synergic extraction of U(VI) by combination of 8-Hydroxyquinoline and neutral donors", *J. Radioanal. Nucl. Chem.*, Letters **94** (1985) 321.

S.N. Pattanaik, D.G. Phal, V.V. Ramakrishna and S.K. Patil, "Absorption spectral studies on the aduct formation between $U(TTA)_4$ and some neutral donours", *Proc. Indian Acad. Sci. (Chem. Sci.)* **95** (1985) 249.

S.G. Marathe, Keshav Chander, N. Raghu and P.R. Natarajan, "Effect of oxalic acid in the potentiometric determination of uranium", *Fres. Z. Anal. Chem.* **321** (1985) 597.

V. Venugopal, R. Prasad and D.D. Sood, "Vaporisation thermodynamics of caesium iodide and caesium chromate", *J. Nucl. Materials* **130** (1985) 115.

D.D. Sood, "Chemical aspects of plutoninum fuels," in *Artificial Radioactivity* (ed. K.N. Rao and H.J. Arnikar), Tata McGraw Hill Pub. Co., New Delhi, 1985; 214.

S.K. Patil, "Some aspects of solution chemistry of actinides", *ibid.*, 231

S.K. Patil, M.V. Ramaniah and S.V. Kumar, "Chemical aspects of neptunium recovery in the purex precess", *ibid.*, 249.

H.C. Jain and S.K. Aggarwal, "Role of alpha spectrometry in nuclear technology", *ibid.*, 263.

D.D. Sood, "Mixed carbide fuels for fast reactors", Radiochemistry and Radiation Chemistry Symposium, Kanpur (1985), 201.

R.V. Kamat, T.V. Vittal Rao, N. Raghu, V.N. Vaidya and D.D. Sood, "Preparation of uranium dioxide microscophers by external gelation process", *ibid.*, 441

"A semi continuous set up for preparation of UO_2 microspheres by internal

gelation process", *ibid.*, 445.

D.G. Phal, R.D. Bhanushali, V.V. Ramakrishna and S.K. Patil, "Ion exchange behaviour of U(VI) and Pu(IV) in nitric acid medium with some macroporous cation exchange resins", *ibid.*, 448.

C.B. Gupta, A.V. Jadhav, K.A. Mathew, P.S. Nair, K. Raghuraman and S.K. Patil, "Some observations on the extraction of Pu(IV)-polymer from nitric acid solutions", *ibid.*, 451.

S.K. Aggarwal, A.R. Parab, S.A. Chitambar and H.C. Jain, "Determination of ^{244}Cm half-life by isotope ratio mass spectrometry", *ibid.*, 246.

G. Chourasiya, S.K. Aggarwal, Radhika Rao, R.K. Duggal, P.A. Ramasubramanian and H.C. Jain, "Determination of plutonium concentration using ^{239} Pu spike in reserse isotope dilution alpha spectrometry without purification from ^{241}Am and a bulk of other impurities", *ibid.*, 528.

K.D. Singh Mudher, A. Chadha, R.R. Khandekar, K. Krishnan and N.C. Jayadevan, "Studies on solid state reaction of ammonium sulphate and ammonium bisulphate with PuO_2 and ThO_2", *ibid.*, 438.

K.V. Chetty, P.M. Mapara, Rajendra Swarup and S.K. Patil, "Synergetic extraction of U(VI) by combination with HTTA and TBP from aqueous thiocyanate medium", *ibid.*, 455.

M.S. Oak, V.B. Sagar, D.R. Ghadse, K.L. Ramakumar and V.K. Bhargava, "A fast dissolution method for mixed-thorium-uranium oxide", *ibid.*, 485.

K.L. Chawla, N.L. Misra and N.C. Jayadevan, "Characterisation of $M_2U_4O_{12}$ type of compounds of potassium, rubidium and thallium", *ibid.*, 525.

S.K. Aggarwal, G. Chourasiya, Radhika Rao, R.K. Duggal, P.A. Ramasubramanian and H.C. Jain, "Studies of the use of non-isotopic diluent in alpha spectrometry: precision and accuracy in alpha activity ratios", *ibid.*, 587.

S.K. Aggarwal, G. Chourasiya, R.K. Duggal, S.A. Chitambar and H.C. Jain, "Studies for high accuracy isotope ratio measurements of plutonium", Third National Symposium on Mass Spectrometry Research, Applications and Instrumentation, Hyderabad 1985; Paper B-1.

S.K. Aggarwal, R.K. Duggal, Radhika Rao, S.A. Chidambar and H.C. Jain, "A comparative study on the use of ^{239}Pu, ^{240}Pu and ^{242}Pu as a spike for determining plutonium concentration by isotope dilution-thermal ionisation mass spectrometry", *ibid.*, Paper B-2.

S.A. Chitambar, P.S. Khodade, A.R. Parab, A.I. Almaula, S.K. Aggarwal and H.C. Jain, "Mass spectrometric determination of ^{238}Pu in the isotopic reference material SRM-947-Pu", *ibid.*, Paper B-3.

S.A. Chitambar, P.S. Khodade, A.R. Parab, A.I. Almaula, S.K. Aggarwal and H.C. Jain, "Determination of ^{240}Pu half-life by relative activity method using ^{238}Pu as a reference isotope", *ibid.*, Paper B-4.

K.L. Ramakumar, P.S. Khadade, A.R. Parab, A.I. Almaula, S.K. Aggarwal S.A. Chitambar and H.C. Jain, "Determination of isotopic composition of boron in B_4C by thermal ionisation mass spectrometry", *ibid.*, Paper B-5

K.L. Ramakumar, V.L. Sant, V.A. Raman, P.A. Ramasubramanian, V.D. Kavimandan, S.K. Aggarwal, C.S. Subbanna and H.C. Jain, "The effect of other major elements on the carbon cluster formation in spark source mass spectrometry", *ibid.*, Paper B-12

K.L. Ramakumar, V.A. Raman, V.L. Sant, V.D. Kavimandan, S.K. Aggarwal and H.C. Jain, "Mass response of the photoplate emulsion in spark source mass spectrometry", *ibid.*, Paper B-13.

K.L. Ramakumar, V.A. Raman, V.L. Sant, V.D. Kavimandan, S.K. Aggarwal, C.S. Subbanna and H.C. Jain, "Application of spark source mass spectrometry to the analysis of high purity materials", *ibid.*, Paper B-14

B.P. Datta, V.A. Raman, V.L. Sant, P.A. Ramasubramanian, Radhika Rao, V.D. Kavimandan and H.C. Jain, "Charge distribution of elements in the spark plasma of U_3O_8 - graphite matrix", *ibid.*, Paper B-15

S.K. Aggarwal, and H.C. Jain, "Lasers and mass spectrometry", *Mass Spectrometry* – Special News Bulletin brought out by ISMAS on the occasion of Third National Symposium on Mass Spectrometry, Regional Research Laboratory, Hyderbad, Sept. 22-24, 1985

S.A. Chitambar, P.S. Khadade, A.R. Parab, A.I. Almaula, R.K. Duggal, S.K. Aggarwal and H.C. Jain, "Determination of curium by alpha spectrometry using ^{233}U as a reference nuclide", Int. Symp. on Artificial Radioactivity, Poona, 1985, Paper RA-3

S.K. Aggarwal, G. Courasiya, R.K. Duggal, C.P. Singh, A.S. Rawat and H.C. Jain, "Investigations on the preparation of sources for alpha spectrometry," *ibid.*, Paper RA-6

S.K. Aggarwal, G. Chourasiya, R.K. Duggal, C.P. Singh, A.S. Rawat, S.A. Chitambar and H.C. Jain, "Experience on the use of ^{239}Pu as a spike for determining the plutonium concentration of isotope dilution mass spectrometry", *ibid.*, Paper RA-7

R.D. Bhanushali, D.G. Phal, R.M. Sawant, K.J. Satao, K.V. Chetty, H.S. Sharma, S.N. Pattanaik, V.V. Ramakrishna and S.K. Patil, "Studies on the use of macroporous resins for laboratory processing of plutonium", *ibid.*, Paper CTE-2

C.B. Gupta, K.A. Mathew, K. Raghuraman, C.K. Sivaramakrishnan and S.K. Patil, "Synergic extraction of curium(III) by HTTA-DBBP mixture", *ibid.*, Paper CTE-4

J.P. Shukla and K.V. Lohithakshan, "Solvent extraction behaviour of some actinides from nitric acid media by dicyclohyxl-18-crown 6," *ibid.*, Paper CTE-5

Rajendra Swarup, A.G. Godbole and N.V. Thakur, "Some studies on the extraction behaviour of actinides with crown ethers", *ibid.*, Paper CTE-6

T.V. Vittal Rao, V.K. Goyal and A.V. Jadhav, "Extraction of plutonium(IV) by dibutyl-N, N-diethyl-carbmoyl methlyl phosphonate from chloride medium", *ibid.*, Paper CTE-7

P.A. Ramasubramanaian, P.M. Shah, V.A. Raman, V.L. Sant, B.P. Datta, K.L. Ramakumar, V.D. Kavimandan, S.K. Aggarwal and H.C. Jain, "Spark source mass spectrometry for the determination of trace constituents in U_3O_8 matrix", Symposium on recent trends in instrumental methods of analysis, Roorkee, 1985, Paper P-15

A.R. Joshi, U.M. Kasar, M.S. Oak, S.M. Pawar, V.B. Sagar and V.K. Bhargav, "Sequential biamperometric determination of uranium and plutonium", International Symp. on Advanced Electroanalytical Techniques, Jodhpur, 1985

N.K. Chaudhuri and M.V.R.Prasad, "Computer methods of calculations for gravimetric multiple standard addition technique of analysis using ion selective electrode", *ibid.*

S.K. Aggarwal, A.R. Parab and H.C. Jain, "Evaluation of alpha spectrum for the determination of plutonium, americium and curium", Topical Meeting on Radiation Spectrometry, Udaipur, 1985; 36.

M.V.R. Prasad, N.K. Chaudhuri and S.K. Patil, "Determination of trace amounts of fluoride in uranium oxide samples by multiple standard addition method using a fluoride ion selective electrode", Symp. on Fundamental and Applied Electorchemistry, Bombay, 1985.

V.K. Bhargava, M.S. Oak, A.R. Joshi, D.R. Ghadse and U.M. Kasar, "The determination of uranium by high precision differential

spectrophotometry", 5th Annual Conf. of Indian Council of Chemists, Dhanbad, 1985

D.R. Ghadse, M.S. Oak and V.K. Bhargava, "Simultaneous spectrophotometric determination of Cu, Ni, Co in a mixture", 22nd Annual Convention of Chemists, Raipur, 1985

P.M. Mapara, S. Negi, V.V. Ramakrishna and S.K. Patil, "Synergic solvent extraction of plutonium(IV) by chloroform or dichloroethane solutions of HTTA and TBP", *ibid.*

A.G. Godbole and Rajendra Swarup, "Synergic extraction of U(VI) by combination of HTTA and crown ethers", *ibid.*

K. Raghuraman, C.K. Sivaramakrishnan and N.S. Sunder Rajan, "Actinide partitioning for high active nuclear waste-potential role of solvent extraction", National Symp. on Solvent Extraction, Madras, 1985

P.M. Mapara, S. Negi, V.V. Ramakrishna and S.K. Patil, "Studies on TBP extraction of plutonium(IV)", *ibid.*

Rajendra Swarup and S.K. Patil, "The extraction of aqueous carboxylate complexes of actinides by long chain amines - A review", *ibid.*

V. Venugopal, V. Sundaresh, K.N. Roy, Ziley Singh, R. Prasad and D.D. Sood, "High temperature enthalpy increments of caesium iodide and caesium chromate", National Symposium on Thermal Analysis, Kharagpur, 1985.

V. Venugopal, N.K. Shukla, V. Sundaresh, K.N. Roy, R. Prasad and D.D. Sood, "Thermochemistry of caesium iodide and caesium chromate", *ibid.*

S. Sampath, S.K. Sali and N.C. Jayadevan, "Oxidation kinetics of uranium-cerium oxides", *ibid.*

A. Chadha, K.D. Singh Mudher, D.M. Chackraburtty and N.C. Jayadevan, "X-ray abd thermal studies on tetraoxalato uranium(IV) complexes of mixed metals", *ibid.*

K.D. Singh Mudher, A. Chadha, K. Krishnan, N.C. Jayadevan and V.V. Deshpande, "Solid state reactions of ammonium sulphate and ammonium bisulphate with uranium dioxide", *ibid*

K.L. Ramakumar, S.K. Aggarwal, S.A. Chitambar and H.C. Jain, "Sequential mass spectrometric analysis of uranium and plutonium employing resin bead techniques", *B.A.R.C.–1289* (1985)

H.C. Jain, "Trace analysis by mass spectrometry", *B.A.R.C/I-842* (1985)

P.M. Mapara, "The chemistry of actinide elements - spectrophotometry of tetravalent actinides", Ph. D. Thesis, University of Bombay, India (1985)

K.L. Ramakumar, "Physico-chemical investigations in nuclear technology: Trace analysis by mass spectrometry", Ph.D. Thesis, University of Bombay, India (1985)

G. Chourasiya, "Physico-chemical investigations in nuclear technology: Determination of irradiated fuel using mass spectrometry and alpha spectrometry", Ph.D. Thesis, University of Bombay, India (1985)

P.N. Bajaj, Hari Mohan and R.M. Iyer, "Studies on transients formed on γ-radiolysis of bromo aromatic compounds in 3-methyl pentane at 77K", *Radiat. Phys. Chem.* **26**(3) (1985) 253.

L.C. Shoute and J.P. Mittal, "Matrix isolation studies of the transients produced in the r-radiolysis of decafluorobenzophenone and triethylamine: radiolytically generated ammonium ion pair of decaflurobenzophenone", *ibid.*, **24** (1985) 459

L.C. Shoute, and J.P. Mittal, "Ionic species produced on γ-radiolysis: studies by matrix isolation technique. Electronic absorption spectra of perfluoro substitued aromatic radical anions", *ibid.*, **26** (1985) 739.

Z. Abdeen, J.M. Bruce, P.N. Guyan, E.J. Land, T. Mukherjee and A.J. Swallow, "Degredation of adriamycin in aqueous sodium hydroxide: formation of a ring-a oxabidononenone", *J. Chem. Res(s)* (1985) 254 & **(M)** (1985) 2882.

M.H. Rao and K.N. Rao, "Radiation induced grafting on to synthetic fibres - a new mechanism of crosslinking and grafting of acrylic acid and acrylonitrile to synthetic fibres", *Radiat. Phys. Chem.* **26** (1985) 669

Manohar Lal, "Radiation induced depolymerisation of hyaluronic acid in aqueous solutions at pH 7·4", *J. Radional. and Nucl. Chem.* **92** (1985) 105-112

Manohar Lal and D.A. Armstrong, "Radiation chemistry of mercaptoethanol in aqueous solution", *Can. J. Chem.* **63** (1985) 30

E.J. Land, T. Mukherjee, A.J. Swallow and J.M. Bruce, "Possible intermediates in the action of adriamycin: a pulse radiolysis study", *British J. Cancer* **51** (1985) 515

P.K. Chowdhury, K.V.S. Rama Rao and J.P. Mittal, "Sensitised decomposition of decafluorocyclohexene by infrared multiphoton excited SF_6 in a CO_2 laser field", *J. Photochemistry* **28** (1985) 503

K.D. Asmus, D. Bahnemann, K. Krisher, M. Lal and J. Monig, "One electron induced dehydration of halogenated methanes and ethane in oxygenated and anoxic aqueous solutions", *Life Chemistry Report* **3** (1985)

V. Parthasarathy, S.K. Sarkar, K.V.S. Rama Rao and J.P. Mittal, "IR Laser photolysis of CDF_3: role of buffer gas on selectivity and yield for deuterium enrichment in fluoroform", *J. Photochemistry* **29** (1985) 333

V. Parthasarathy, S.K. Sarkar, K.V.S. Rama Rao and J.P. Mittal, "Selective IR laser chemistry of CDF_3 in natural fluoroform", *Applied Physics* **(B)** *Laser Chemistry and Photophysics* **B39** (1986) 7

S.N. Guha, P.N. Moorthy and K.N. Rao, "Transient spectra and decay kinetics of semithionine radicals in sodium dodecyl sulphate micellar media", *J. Photochemistry* **28** (1985) 37

A.R. Gupta and Deoki Nandan, "Hydrogen isotope effects in the dehydration of polystyrene divinyl benzene type ion exchange resins and the structure of electrolyte solutions II, Na^+, K^+ and Cs^+ forms of Dowex 50W resins", *J. Phys. Chem.* **89** (1985) 4329

S.K. Kulshreshtha, N.M. Gupta, Krishna Mishra, P. Suryanarayana and R.M. Iyer, "Study on catalytic behaviour of Fe-Ti for CO methanation reactions", *Adv. Catalysis Science and Technology*, Wiley Eastern Ltd., 1985; 1-8

V.S. Kamble, N.M. Gupta and R.M. Iyer, "Oxygen and hydrogen reactivity of laid down carbonaceous species deposited by ethylene on supported Ru catalysts", *ibid.*,9-18

R.M. Iyer, "Dynamics of surface reactions of CO, CO_2, C_2H_4 and CS_2 over ruthenium", *Proc. Indian Nat. Sci. Acad.* **51**(*1*) (1985) 290

V.M. Shirsat and K.S. Bhatki, "Spectral changes in the formation of nickel oxinate monohydrate - a transient species in chloroform", *Spectrochim. Acta* **41A** (1985) 491.

A.R. Gupta, "An interpretation of water sorption isotherms in ion exchange resins", *Ind. J. Chem.* **24** (1985) 368

K.S. Bhatki, "Metal chelates of resacetophenone oxime", *Rev. Anal. Chem.* **VIII** (3) (1985) 211-228

K.S. Bhatki, "Adduct formation by the oxinates of certain metals", *Talanta* **32** (*8B*) (1985) 833-837

V.M. Shirsat and K.S. Bhatki, "Adduct formation of zinc oxinate chelate with some nitrogen bases", *Spectrochim. Acta* **41A** (*11*) (1985) 1349

B.S. Valaulikar and C. Manohar, "The mechanism of clouding in Triton X–100: the effect of additives", *J. Colloid and Interface Science* **108** (1985) 403.

B. Venkataramani, A.R. Gupta and R.M. Iyer, "Effect of in situ γ-irradiation on the sorption properties of hydrous oxides", *J. Radioanal. and Nucl. Chem.* **96** (1985) 129

S.K. Kulshreshtha, R. Sasikala and E. Konig, "Calorimetric investigations of low spin ($^1A_1$) ⇄ high spin ($^5T_2$) transition in solid dithiocyanato bis (2,2'-bi-2 thiozoline) iron (II)", *Chem. Phys. Letters* **123** (1986) 215.

S.K. Kulshreshtha and G. Ritter, "Mossbauer study of $Li_{0.5}Fe_{2.5-X}Al_XO_4$. Cation distribution and noncollinear spin alignments", *J. Mat. Sci.* **20** (1985) 821

D.D. Pruthi, "Calculation of solute vacancy binding energy in dilute fcc and bcc alloys by diffusion", *Bill. Mater. Sci.* **7***(1)* (1985) 43

M.S. Anand, W. Mansel, G. Wallner and W. Weck, "Damage rate measurement at 4·6K and recovery studies in zirconium and zirconium-tin alloys", *Radiation effects* **89** *(324)* (1985) 179

J.V. Yakhmi, I.K. Gopalkrishnan and R.M. Iyer, "Some anomalous aspects of resistivity behaviour in dilute chromium alloy systems", *J. Appl. Phys.* **57** *(8)* (1985) 3223

J.V. Yakhmi, I.K. Gopalkrishnan, R.M. Iyer and L.C. Gupta, "Spin density wave antiferromagnetism in chromium as influenced by some transition metal impurities", *Ind. J. Phys.* **59***(A)* (1985) 477

S.M. Sharma, V. Vijaykumar and S.K. Sikka, "High pressure phase in organic solids I. $\alpha-\beta$ transition in resorcinol", *Pramana J. Phys.* **25** (1985) 75

S.K. Kulshreshtha and G. Ritter, "Mossbauer studies of $Li_{0.5}Fe_{2.5-x}Ga_xO_4$ system Canted spin alignment and cation distribution", *J. Mat. Science* **20** (1985) 3926

P. Raj and A. Sathyamurthy, "On the acid hydriding and activation of FeTi", *J. Less Common Metals* **115** (1986) 235-241

S.N. Vaidya, "Theory of melting:II. Relaxion model", *Physica status solidi (a)* **87** (1985) 181

S.N. Vaidya, "Theory of melting: III. Nature of the molten glasses", *ibid.*, **91** (1985)37

A.K. Dua, R.P. Agarwala and P.B. Desai, "Preparation and characterisation of beryllium coatings", *J. Vac. Sci. and Tech. (A)*, **3** *(6) (1985) 2612*

S.K. Kulshreshtha, "Cation distribution and canted spin alignment in $LiFeTiO_4$", *J. Magn. Mater*, **53**, (1986) 345

S.G. Deshpande, S.C. Jain, H.C. Ahuja and G.S. Rao, "N, N-dimethyl thiocarbamato complexes of uranium", *Indian J. Chem. A***24** (1985) 705

H.S. Ahuja, S.B. Karweer, V.S. Sagoria and S.C. Jain, "Dinitrile complexes of uranium (IV) halides," *ibid.*, 871.

V.M. Padmanabhan, R.P. Patel and T.N. Ranganathan,"Structure of trans-dichloro bis (p-fluoroaniline) palladium(II)", *Acta Cryst.* **C41** (1985) 1305

H.C. Clark, V.K. Jain and G.S. Rao, "Preparation and characterisation of mercapto bridged dinuclear platinum(II) complexes. Catalytic activity of $[(PEt_3)\ PtCl(u\text{-}SEt)]_2$ / $SnCL_2{\cdot}2H_2O$ system in hydrogenation and hydroformylation of styrenl," *J. Organomet. Chem. 279* (1985) 181

E. Konig, G. Ritter and S.K. Kulshreshtha, 'Nature of spin state transition in solid Fe(II) complexes and its interpretation of some associated phenomena", *Chem. Rev.* **85** (1985) 219

T. Mukherjee and J.P. Mittal, "Energy transfer from benzene to some hydrocarbons and their perfluorinated analogues", *Ind. J. Chem. (Sec A)* (1986, in print)

C. Gopinathan and S. Kapoor, "Hydrogen peroxide yields in methanol water glasses irradiated at room temperature and at 77K", *Radioanal. and Nucl. Chem.* (1986, in print)

D.K. Palit, T. Mukherjee and J.P. Mittal, "Photophysics and laser flash photolysis of hydroxyquinones: studies on juglone and naphthazarin", *J. Ind. Chem. Soc.* (1986, in print)

R.D. Saini and P.K. Bhattacharyya, "Flash photolytic investigation on the reaction between Pu(IV) and CO_3 in alkaline medium", *Radiat. Phys. Chem.* (1986, in print)

L.C.T. Shoute and J.P. Mittal, "Studies on the transients generated in the γ-radiolysis of benzoyl-1, 1, 1, trifluoroacetone in glassy matrices - the radiolytically induced ketonisation", *ibid.* (1986, in print)

M. Kumar, M.H. Rao and K.N. Rao, "Gamma radiolysis of polycyclohexyl methacrylate", *ibid.*, (1986, in print)

S. Kapoor and C. Gopinathan, "Electron scavenging by solutes in ethylene glycol-water glasses at 77K", *ibid.*, (1986, in print)

S. Dhanya, R.D. Saini and P.K. Bhattacharyya, "Reaction of electronically excited benzene molecute with nitrate ion", *Chem. Phys. Letters.* (1986, in print)

D.B. Naik and P.N. Moorthy, "Photoprocesses in sodium decyl sulphate micellar media", *Proc. Indian Acad. Sci.* (1986, in print)

Manohar Lal, J. Monig and K.D. Asmus, "Free radical induced degradation of 1, 2, dibromoethane generation of free Br atoms", *Free Radical Research* (1986, in print)

P.K. Chowdhury, K.V.S. Rama Rao and J.P. Mittal, "Infrared multiphoton induced concerted : CF_2 elimination in octafluorocyclopentene by a pulsed CO_2 laser", *J. Physical Chemistry* (1986, in print)

S.K. Sarkar, V. Parthasarathy, K.V.S. Rama Rao, and J.P. Mittal, "IR multiphoton excitation in CDF_3 probed by pulsed opto-acoustic technique", *J. Photochemistry* (1986, in print).

D.D. Bhawalkar, U.K. Chatterjee, J.P. Mittal, K.V.S. Rama Rao, S.K. Sarkar, N.S. Shikharkhane, V.S. Letokhov and A.A. Puresky, "Highly efficient multiphoton dissociation of CDF_3 in two frequency laser fields", *Laser Chemistry* (1986, in print).

T. Mukherjee, K.N. Rao and J.P. Mittal, "Photophysical and photochemical Characteristics of two heterocyclic dyes", *Ind. J. Chem.* (1986, in print).

L.V. Shastri, Lalitha J. Mittal and J.P. Mittal, "Primary processes in the radiation chemical reduction of Eu(III) ions in Lanthanide mixtures" *Radiat. Phys. Chem.* (1986, in print).

A.P.G. Kutty and B.K. Sinha, "Theory of Raman scattering for a laser produced plasma with an exponential profile", *Phys. of Fluids* (1986, in print)

V.P. Oze and K.S. Bhatki, "Formation constants of adducts of some zinc oxinate chelates with nitrogen bases", *Indian J. Chem.* (1986, in print).

V.P. Oze and K.S. Bhatki, "Adduct formation between zinc oxinate and some heterocyclic nitrogen bases. A spectrophotometric study", *Indian J. Chem.* (1986, in print).

V.K. Kelkar and C. Manohar, "A theoretical model for the phase diagram of mixtures of nematic liquid crystals and polymeric solutes", *Molecular Cryst. Liq. Cryst.* (1986, in print).

C. Manohar, U.R.K. Rao, B.S. Valaulikar and R.M. Iyer, "On the origin of viscoelasticity in micellar solutions of CTAB and sodium salicylate", *J. Chem. Soc. Chem. Comm.* (1986, in print).

A.A. Majmudar and A.R. Gupta, "Complexation of hydrogen ions with 18 crown 6 in aqueous solutions", *Indian J. Chem.* (1986, in print).

A.R. Gupta, "A generalised approach to study metal ion complexes by ion exchange techniques based on distribution methods", *Indian J. Chem.* (1986, in print).

C.G.S. Pillai and A.M. George, "Thermal conductivity of La_2CuO_4, La_2NiO_4 and Nd_2CuO_4 in the semiconducting and metallic phases", *Int. J. Thermophysics*

S.K. Kulshreshtha, "Cation distribution and canted spin alignment in $NiFeAlO_4$", *J. Mat. Sci.Letters* (1986, in print)

Sandhya Bhakay, Tamhane, C. Karunakaran and S.N. Vaidya, "Critical point in the phase diagram of $LiKSO_4$", *High Temp. High Pressure* (1986, in print)

S.N. Vaidya and D.K. Joshi, "Effect of pressure on the eutectic temperature in systems Au-Si and Ni-Ge", *J. Less Common Metals* (1986, in print)

P. Raj, A. Sathyamoorthy, P. Suryanarayan and R.M. Iyer. "Nickel-substituted FeTi hydrides: a critical study of β-region", *J. Less Common Metals.* (1986, in print)

G.L. Goswami, P.K.K. Nair, P. Raj and G.P. Tiwari, "Acoustic emission studies of structural relaxation", *J. Acoustic Emission* (1986, in print).

S.C. Jain, M.S. Gill and G.S. Rao, "Coordination compounds of uranium(IV) and dioxouranium (VI) with nitrogen containing heterocylic ligands", *J. Ind. Chem. Soc.* (1986, in print).

M.S. Gill, "Vapour pressure of bis-C1,1,1,5,5,5,-hexafluoro 2,4 pentane dionato) dioxo-uranium tetra-hydrofuran", *Thermochim. Acta* (1986, in print).

R.P. Patel, T.N. Ranganathan and V.M. Padmanabhan, "Structure of bis(4-hydroxy-l-prolinato) palladium(II) trihydrate", *Acta Cryst.* C. (1986, in print)

Hari Mohan and A.J. Singh, "Zone-refined tetraphenyl germane", *Indian J. Chem.* (1986,in print)

M. Kumar and M.H. Rao, "Radiation initiated grafting of styrene on to wool", *J. Appl. Polymer Sci.* (1986, in print).

T. Mukherjee, I. Rau, A.M. Wani and J.P. Mittal, "Adenosine-sensitised photolysis of alamine", *Chemistry Letters* (1986, in print).

Kamal Kishore, P.N. Moorthy and K.N. Rao, "Reactivity of H_2O_2 with radiation produced free radicals: steady state radiolysis method for estimating the rate constants", *Radiat. Phys. Chem.* (1986, in print).

S.K. Kulshreshtha, S.B. Srivastava, V.G. Thomas and P. Raj, "Chemical after effects of nuclear transformation in Sn(IV) complexes: A Sn^{119} Mossbauer and radiochemistry study", *Radiochim. Acta.*.

S.K. Sarkar V. Parthasarathy, K.V.S. Rama Rao and J.P. Mittal, "Infrared fluorescence studies in the infrared MPD of CDF_3 - CHF_3 system", *J. Photochemistry* (1986, in print)

R. Rojer, M.H. Rao and K.N. Rao, "Radiation polymerization of cyclohexylacrylate", *Radiat. Phys. Chem.* (1986, in print).

R. Roger, M.H. Rao and K.N. Rao, "Radiation polymerization of cyclohexyl acrylate in presence of cyclohexanol - Part II", *Radiat. Phys. Chem.* (1986, in print)

R. Roger, M.H. Rao and K.N. Rao, "Radiation induced polymerization of cyclohexyl acrylate in the presence of hydroquinone - Part III", *Radiat. J. Chem.* (1986, in print).

S.N. Guha, D.B. Naik and P.N. Moorthy, "Photoredox reactions in the thionine ferrous system in macromolecular environment", *Ind. J. Chem.*

M. Lal, J. Monig and K.D. Asmus, "Acid formation in the radical mediated degradation of chlorinated ethane in aqueous solutions", *Environmental Science and Technology* (1986, in print)

M.H. Rao, K.N. Rao, M.D. Teli, A.G. Jog and H.T. Lokhande, "Grafting of polypropylene fibres - 1. Radiation grafting of vinyl monomer dyeing and hydrophilic characteristics of the grafted polymer," *J. Appld. Polymer Science* (1986, in print)

H.T. Lokhande, A.G. Jog, M.D. Teli, M.H. Rao and K.N. Rao, "Grafting of polypropylene fibres - II. Electrokinetic properties of grafted polypropylene fibres", *ibid.*, in print.

H.T. Lokhande, A.G. Jog, M.D. Teli, M.H. Rao and K.N. Rao, "Grafting of polypropylene fibres - III. Electrical conductivity of grated fibres", *ibid.*, in print.

M.H. Rao, K.N. Rao, H.T. Lokhande and M.D. Teli, "Radiation induced grafting of mixed monomers on to polyester and polypropylene fibres", *ibid.*, in print.

A.P.G. Kutty, "Ground states of mixed valence materials", *J. Phys.* (C) (1986, in print)

R.G. Majid and Deoki Nandan, "Hydrogen isotopes effects in the ammonium ion(aq)/water exchange and the distillation of ammonium chloride solutions at 373K", *Indian J. Chem.* (1986, in print).

K. Kishor and P.N. Moorthy, "Interaction of metal ions with surfactant micelles", *J. Colloid and Interf Science.*(1986, in print)

R.P. Agarwala, "Point defect interaction in dilute betazirconium alloys", *J. Ind. Chem. Soc.* (1986, in print)

C.G.S. Pillai, M.D. Mathews, A.C. Momin and A.M. George, "Electrical conductivity of strontium uranates", *J. Nucl. Materials* (1986, in print).

R. Visalakhsi, V.K. Jain, S.K. Kulshreshtha and G.S. Rao, "Studies on some diorgano tin(IV) complexes of bis-and tris - pyrazolyl and bis pyridyl methanes and pyridyl pyrazoles", *Inorg. Chemica Acta.* (1986, in print)

M.S. Sastry and M.D. Sastry, "Stereochemistry and structural phase transitions of Cu(II) complexes containing orthophosphate ions and pyridine / γ picoline", *Proc. Ind. Acad. Sci. (Chem. Sci.)* (1986, in print).

V.K. Jain and G.S. Rao, "Mixed chloro-mercapto bridged dinuclear platinum(II) complexes and their catalytic activity in homogeneous hydrogenation", *Chem. Soc. Dalton Trans.* (1986,in print)

V.K. Jain, G.S. Rao and L. Jain, "The organic chemistry of platinum (IV)", *Adv. Organomet Chem.* (1986, in print),

J.P. Mittal, "Time resolved pulse radiolysis", Science Congress, Lucknow, Jan. 3-6, 1985 - Invited Talk.

J.P. Mittal, "Excimer Laser photochemistry", National Symp. on Photochemistry, Madras, Feb. 9-11 1985 - Invited Talk.

J.P. Mittal, "Cracking molecules to order", Seminar on Update in inorganic and physical chemistry, Indian Institute of Science, Bangalore, 13 1985 - Invited Talk.

P.K. Chowdhury, K.V.S. Rama Rao and J.P. Mittal, "Resonant photon absorption by octafluorocyclopentene", Symp. on Quantum Electronics, BARC, Jan 14-16,1985

V. Parthasarathy, S.K. Sarkar, K.V.S. Rama Rao and J.P. Mittal, "Selective IR laser photochemistry of CDF_3 in natural fluoroform", *ibid.*

J.P. Mittal, "Calutrons to lasers", International Symp. on Artificial Radioactivity, Poona, Jan 8-12,1985 - Invited Talk.

M.Lal, L. Monig and K.D. Asmus, "Radiolytical studies on the free radical mediated generation of acids from halogenated solutions", *ibid.*

S.Kapoor and C. Gopinathan, "Scavenging of trapped electrons in methanol-isopropanol glasses at 77K", *ibid.*

M. Kumar and M.H. Rao, "Gamma radiolysis of polycyclohexyl methacrylate", *ibid.*

S.N. Guha and P.N. Moorthy, "Radiolytic reduction of uranyl ion in aqueous acidic solutions", *ibid.*

D. Prasad and K.V.S. Rama Rao, "Radiation induced changes in the oscillatory period of Belousov - Zhobotinskii Chemical Oscillator", *ibid.*

T. Mukherjee, "Determination of ionic charge of semiquinones: pulsed conductivity and ESR techniques", *ibid.*

P.K. Chowdhury, K.V.S. Rama Rao and J.P. Mittal, "Gas phase unimolecular dissociation kinetics of cyclic perfluoro olefins", International Conf. on Chemical Kinetics, NBS, Washington D.C., June 17-19, 1985.

Lalitha J. Mittal and J.P. Mittal, "Reactivity and percentage determination in the hydrated electron reactions with alkyl amines", *ibid.*

M. Kumar and M.H. Rao, "Radiation induced copolymerization of methacrylic acid and methyl methacralate", DAE Symp. Radiochemistry and Radiation Chemistry, Kanpur, Dec 1985.

M. Lal and K.D. Asmus, "OH radical and e^-_{aq} induced degration of 1, 2 dibromoethane in aqueous solutions", *ibid.*

S.Kapoor and C. Gopinathan, "Electron trapping in methanol-isopropanol glasses at 77K", *ibid.*

P.N. Bajaj, Hari Mohan and R.M. Iyer, "Matrix isolation study of transients produced on γ-radiolysis of phenyl cyclohexane in organic glasses at 77K", *ibid.*

P.K. Bhattacharyya, "Radiation chemistry of actinides and process materials," *ibid.*

T. Mukherjee, "Radiation chemistry of juglone", *ibid.*

L.C.T. Shoute and J.P. Mittal, "Gamma radiolysis studies on the kinetics of ionic decay in 3-methyl pentane at 77K", *ibid.*

L.C.T. Shoute and J.P. Mittal, "Radiation effects on end-keto-tautomerism of fluorinated 1,3 dicarbonyl compounds", National Symp. fluorine containing compounds, Chandigarh, Oct 1985.

P.K. Chowdhury, K.V.S. Rama Rao and J.P. Mittal, "Pericyclic reactions of perfluorocyclic olefins induced by pulsed infrared laser", *ibid.*

P.K. Chowdhury, S.K. Sarkar, K.V.S. Rama Rao and J.P. Mittal, "Time resolved infrared chemiluminescent studies on reaction of $:CF_2$ radical with oxygen", National Conf. on Theoretical Chemistry and Spectroscopy, Calcutta, Dec 1985.

J.P. Mittal, "Laser flash photolysis and pulse radiolysis as complementary probes of reaction dynamics", *ibid* - Invited Talk.

S.K. Sarkar, V. Parthasarathy, K.V.S. Rama Rao and J.P. Mittal, "Pulsed opto acoustic measurements of TEA-CO_2 laser induced multiple photon excitation in fluoroform-d", *ibid.*

P.N. Bajaj, S.K. Sarkar, R.K. Talukdar, K.V.S. Rama Rao, J.P. Mittal and P.K. Chakraborti, "Infrared laser-induced dissociation of large uranium bearing molecules", *ibid.*

P.N. Moorthy, S.N. Guha and D.B. Naik, "The excited state properties and photoredox reactions of thiazine dyes in micellar and macromolecule systems," XIIth International Conf. on Photochemistry, Tokyo, Aug 4-9, 1985.

T.G. Dhanya, R.D. Saini and P.K. Bhattacharyya, "Photochemistry of aqueous nitric acid", *ibid.*

R.D. Saini, P.K. Bhattacharyya and R.M. Iyer, "Photochemistry of uranyl carbonate complexes", *ibid.*

P.N. Moorthy and Kamal Kishore, "Surfactant effects in electrochemical and electroanalytical systems", International Symp. on Advanced Electroanalytical Techniques, Jodhpur, Dec 22-28, 1985 - Invited Talk.

M.H. Rao, "Radiation processing for producing improved materials", Management appreciation programme on application of radioisotopes in defence R and D - Production and Quality Assurance, Jodhpur, Dec., 1985 - Invited Talk.

P.N. Moorthy and Kamal Kishore, "40 MeV α-radiation enhanced catalytic activity of β-MnO_2", Workshop on utilization and future programmes of VEC, Abstract book p39 (I 23).

K.N. Kirti, S. Sengupta, T.S. Iyengar, S. Somasunderam, P.N. Moorthy and R.M. Iyer, "Safety considerations in the operation of a 7 MeV Electron Linear Accelerator", Thirteenth Conf. on Radiation Protection,IARP, VEC, Calcutta, March, 1986.

C. Manohar, "Systems with large surfaces", Symp. on Surface Physics, Lucknow, Jan 6, 1985 - Invited Talk.

C. Manohar, "Ralation between structure and reaction rate in microemulsions", International Symp. on Reactions on Micellar and Membrane Surfaces, Sambhalpur Univ., Jan 20, 1985 - Invited Talk

R. Leung, M.J. Hou, C. Manohar, D.O. Shah and P.W. Chun, "Micro and macroemulsion reaction kinetics as a probe for dynamic structure", ACS Symp. Series No. 272, Ed. D.O. Shah, 325 (1985).

M.S. Panajkar and T.S. Hari Rao, "Electron impact and chemical ionization mass spectral studies of some isomeric organic compounds", Third National Symp. on Mass Spectrometry: Research, Application and Instrumentation, R.R.L, Hyderabad, Sept., 1985.

A.S. Veer Raj Urs, M.S. Panajkar and T.S. Hari Rao, "Development of microprocessor based data system for a Mass Spectrometer", *ibid.*

Deoki Nandan, "Preparation of liquid water standards of low deuterium concentration using deuterium ratio mass spectrometer", *ibid.*

N.M. Gupta, G.E. Prasad, S.K. Sharma and R.M. Iyer, "Characterisation of a deactivated deuterium exchange catalyst", IIIrd National Workshop on Catalysis and Catalysts, Bhubaneswar, Feb, 1985.

B. Venkataramani, "Extraction of uranium from sea water", Radiochemistry and Radiation Chemistry Symp., I.I.T, Kanpur, Dec, 1985 - Invited Talk.

A.P.G. Kutty, "Ground state of Sm compounds", DAE Symp. on Nucl. Phys. Solid State Phys., Nagpur, Dec, 1985.

M.G. Ramchandani, "Energy band structure of potassium metal", *ibid.*

J.V. Yakhmi, I.K. Gopalakrishnan, R.M. Iyer and L.C. Gupta, "Spin density wave antiferromagnetism in chromium as influenced by some transition metal impurities", National Seminar on Solid State Physics, Jadavpur, Feb, 1985.

A.K. Dua, R.P. Agarwala and P.B. Desai, "Preparation and characterisation of beryllium coatings", Int. Conf. Metallurgical Coatings, Los Angeles, Apr 15-19, 1985.

A.M. George, M.A. Vaidya, A.B. Phadnis and V.V. Deshpande, "Reactions of hydrated zirconia with calcium oxide, carbonate and oxalate", Vth National Symp. and Workshop on Thermal Analysis, Kharagpur, Dec, 1985.

A.K. Dua and R.P. Agarwala, "Preparation and characterisation of Ga_2Se_3 thin films", Solid State Physics Symp. , Nagpur. Dec., 1985.

D.D. Pruthi and M.S. Anand, "Radiation enhanced self diffusion in silver", *ibid.*

S.K. Kulshreshtha, "Cation distribution and canted spin alignment in $NiFeALO_4$", *ibid.*

P. Raj and A. Sathyamoorthy, "Hydrogen diffusion in $(Fe_{1-x}\ Ni_x)Ti$ hydride using Mossbauer Studies", *ibid.*

J.V. Yakhmi, I.K. Gopalkrishnan, R.M. Iyer and J.L. Stanford, "Magnetic behaviour of CrAl single crystal from electrical resistivity measurements", *ibid.*

J.V. Yakhmi, I.K. Gopalkrishnan, L.C. Gupta and R.M. Iyer, "Influence of Ir-impurity on the formation of local moments on vanadium in Cr-matrix," *ibid.*

B.M. Pande, M.S. Anand and R.P. Agarwala, "Dose and energy dependence of helium ion irradiated model", Int. Symp. on Effect of Radiation on Materials, Seattle, Washington, June 23-25, 1986.

R.P. Agarwala, A.K. Dua and B.M. Pande, "Characterisation of TiC coatings and its radiation behaviour", 2nd Int. Conf. on Fusion Reactor Materials, Chicago, April 13-17, 1986.

A.K. Dua, B.M. Pande and R.P. Agarwala, "Study of deuterium irradiated carbon coatings by SEM", XVII Annual Meeting of Electron Microscope Society of India, Chandigarh, 1986.

S.C. Jain, S.G. Deshpande and G.S. Rao, "Mixed ligand complexes of uranium", Convention of Chemists, Raipur, (1985).

C. Gopinathan, "State of the art in hemodializers", XIth All India Symp. cum Workshop on Biomedical Engg., Bombay, Dec, 1985 - Invited Talk.

C. Gopinathan, T.P. Balan and K. Sundaram, "Hydrophillic polymers in biomedicine", Int. Workshop on Molecular Biosciences and Biotechnology, Madras, Aug, 1985 Invited Talk.

S.C. Tripathi, A. Ramanujam, M.N. Nadkarni, K. Annaji Rao and C. Bandopadhyay, "Chromatographic assay of degradation products of tributyl phosphate", *BARC– 1272* (1985).

J.T. Kunjappu, "Photo and radiation effects on some organic molecules like vinyl monomers and laser dyes: studies on laser dyes - Photochemical effects on trans–4,4'-diphenyl stilbene and 7-amino-4methyl coumarin", Bombay University (Thesis) (1985).

A method for manufacturing mechanically stable three dimensionally cross linked polyvinyl alcohol, use of mechanically stable three dimensionally cross linked polyvinyl alcohol. Patent application accepted (1985), No. 153994.

A method of removing human blood toxins. Patent application accepted (1985), No. 153999.

Publications

Yields of rare earth fission products in the spontaneous fission of Cf–252, B. S. Tomar, H. Naik, A. Ramaswamy and Satya Prakash, J. Radioanal. Nucl. Chem. **91**(2), 291 (1985).

Characterisation of UO_2 powders by radioactive adsorption, G. P. Tiwari, N. C. Soni, A.G.C. Nair and Satya Prakash, J. Nucl. Materials **127** (1985).

Cumulative yields of short-lived ruthenium isotopes in the thermal neutron fission of U–233, U–235 and Pu–239, A. G. C. Nair, Alok Srivastava, A. Goswami and B. K. Srivastava, J. Radioanal. Nucl. Chem. **91,** 73 (1985).

Alpha induced fission of Bl–209, S. S. Rattan and R. J. Singh, Radiochimica Act a **38**, 69 (1985).

Charge transfer interaction of trivalent lanthanides and actinides with B–diketones, J. N. Mathur and P. K. Khopkar, Inorg. Chim. Acta "of block elements" **109** L19–L20 (1985).

Ion exchange behaviour of chelating resin Dowex–1 with actinides and lanthanides, J. N. Mathur and P. K. Khopikar, Solv. Extn. Ion Exch. **3**(5), 753 (1985).

Synergistic extraction of uranyl ion with 1–phenyl–3–methyl–4–benzoyl–pyrazolone—5 (HPMBP) and diphenyl sulphoxide (DPSO), tri–N–butyl phosphate (TBP) or tri–N–octyl phosptrine oxide (TOPO), S. A. Pai and M. S. Subramanian, J. Radioanal, Nucl. Chem. Articles 89/2, 423 (1985).

Thermodynamics of interaction of lanthanum (III) with 1–phenyl–3–methyl–4–benzoyl–pyrazolone–5 in aqulous dioxane, J. P. Shukla, P. M. Ravi and M. S. Subramanian, Thermochimica Acta **84**, 207 (1985).

On the use of hydrogen peroxide as masking agent for the dltermination of yttrium in uranium oxide-yttrium oxide mixture, R. K. Rastogi. G. H. Rizvi, N. K. Choudhary and M. S. Subramanian, J. Rodioanal. Nucl. Chem. Letters 96/5, 489 (1985).

Determination of the stability constants of Np (V) fluoride complex using a fluoride ion selective electrode, R. M. Sawant, G. H. Rizvi, N. K. Chaudhuri and S. K. Patil, J. Radioanal. Nucl. Chem. Articles **89**(2), 373–378 (1985).

Studies on fluoride complexing of hexavalent actinides using a fluoride Ion selective electrode, R. M. Sawant, N. K. Chaudhuri, G. H. Rizvi and S. K. Patil, J. Radioanal. Nucl. Chem. Articles **91**(1), 41–58 (1985).

A conductivity method for the determination of combined carbon and free carbon in uranium carbide, C. H. Rizvi, A. De and P. R. Natarajan, J. Radioanal. Nucl. Chem. Letters, **103**(2), 95–104 (1986).

Gas chromatographic analysis of high purity helium at subambient pressure, S. C. Kulkarni, G. A. Rama Rao, V. K. Manchanda and P. R. Natarajan, J. Chrom. Sci. **23**, 68 (1985).

Studies on the adsorption of americium on alumina from aqueous nitric acid–oxalic acid solutions, M. Subba Rao, A.M. Gaikwad, V. K. Rao and P. R. Natarajan, Sep. Sci. & Tech. **20**, 205 (1985).

Potetiometric determination of uranium in the presence of plutonium in H_2SO_4 medium, N. Gopinath, G. A. Rama Rao, V. K. Manchanda and P. R. Natarajan, J. Radiochem. Nucl. Chem. Letters **96**, 273 (1985).

Titrimetric determination of uranium in the presence of plutonium in sulphuric acid medium, G. A. Rama Rao, V. K. Manchanda and P R. Natarajan, J. Radioanal. Nucl. Chem. Letters **94**,95 (1985).

Effect of oxalic acid in the potentiometric determination of uranium, S. G. Marathe, N. Raghu, Keshav Chander and P. R. Natarajan, Z. Anal. Chem. **321**,597 (1985).

An improved method for the potentiometric determination of plutonium using Cerium (IV) as an oxidant, G. R. Mahajan M. M. Charyulu, V. K. Rao and P. R. Natarajan, J. Radioanal. Nucl. Chem. Letters,**96**, 1 (1985).

Trap level spectroscopy of $BaCO_3$:Eu and $BaCO_3{}^{241}$ Am phosphors, V. Natarajan, A. G. I. Dalvi and M. D. Sastry, Radiation Effects, 1985.

EPR studies of phase transitions in $(NH_4)_3 H(SO_4)_2$ single crystals, D. Suresh Babu, G. S. Sastry, M. D. Sastry and A. G. I. Dalvi, J. Phys. C. Solid St. Phys. **18**,111 (1985).

A highly sensitive extractive photometric method for the micro–determination of Am(III), J. P. Shukla, V. Shivarudrappa, P. D. Mithapara and P. R. Natarajan, J. Radioanal. Nucl. Chem. Articles **100** (1), 83 (1986).

Precipitation of plutonium oxalate from homogeneous solutions, V. K. Rao, I.C. Pius, M. Subba Rao, A. Chinnusamy and P. R. Natarajan, J. Radional. Nucl. Chem. Articles **100**(1), 129 (1986).

Studies on plutonium (IV) hydroxoauccinate, M. S. Nagar, P. B. Ruikar and M. S. Subramanian, J. Radioanal. Nucl. Chem. Articles **99**, 1, 109 (1986).

Liquid-liquid extraction of trivalent actinides and lanthenides with N–benzoyl–N–phenyl hydroxylamine, J. N. Mathur and P. K. Khopkar, Radiochim. Acta (In Press)

Fragment shell effect in low energy fission: Isotopic yield of technitium in Pu–239 (n,f), Alok Srivastava, A. Goswami, B. K. Srivastava, A. G. C. Nair, S. B. Manohar, Satya Prakash and M. V. Ramaniah, Phys. Rev. C. (In Press).

Influences of fragment nuclear structure on scission configuration in Cf–252 (SF), T. Datta, S. P. Dange, S. K. Das, Satya Prakash and M. V. Ramaniah, Z. Physik. A. (In Press).

Correlation between fractional cumulative yields and neutron to proton ratio of fission products in low energy fission, A. Goswami, B. K. Srivastava, Alok Srivastava, S. B. Manohar, Satya Prakash and M. V. Ramaniah, Pramana (In Press).

Dependence of fragment angular momentum of fission fragments on their nuclear structure, S. P. Dange, H. Naik. T. Datta, A.V.R. Reddy, Satya Prakash and M. V. Ramaniah, Radiochimica Acta (In Press).

Studies on the electrodeposition of uranium on aluminium, N. N. Mirashi, J. N. Mathur, Satya Prakash and M. V. Ramaniah, Int. J. Appl. Radiat. Isotopes (In Press).

Alpha induced reactions of Bi–209 and Cu–63, 65, S. S. Rattèn, R. J. Singh, S. M. Sahakundu, Satya Prakash and M. V. Ramaniah, Radiochimica acta (In Press).

Fission fragment angular momentum : Independent yield ratios of Cs–138 in the thermal neutron induced fission of U–233, Pu–239 and Pu–241, B. S. Tomar, A. Goswami, S. K. Das, T. Datta, Satya Prakash and M. V. Ramaniah, Radiochimica Acta (In Press).

LPR studies of structural phase transitions in Langebinites II, D. Suresh Babu, G. S. Sastry, M. D. Sastry and A. G. I. Dalvi, J. Phys. C Soild St. Physics (Accepted for publication)

Atomic absorption spectrometric studies of atomization of boron in carbon rod atomizer, N. Goyal, A. R. Dhobale, B. M. Patel and M. D. Sastry, Analytics Chimica Acta (Accepted for Publication).

Theoretical principles of atomic absorption spectrometry, M. D. Sastry, Workshop on Analytical Spectroscopy, IGCAR, Kakpakkam, Oct. 31–Nov. 2 (1985).

Inductively coupled plasma emission spectrometry, M. D. Sastry, ibid.

Characterisation of nuclear materials by optical emission spectroscopy, M. D. Sastry, ibid.

Trace metal assay of uranium–aluminium alloy by atomic emission spectrometric method, S. K. Thulasidas, A. A. Argekar, M. J. Kulkarni, S. V. Godbole, A. G. Page and M. D. Sastry, Convention of Chemists, Raipur, Nov. 4–8 (1985).

Direct determination of Ag, Cd, Li and Na in uranium–plutonium solution by ETA–AAS method, Neelam Goyal, P. J. Purohit, M. J. Kulkarni, A. G. Page and M. D. Sastry, ibid.

Separation of Am (III) and Cm (III) using chelating and anion exchange resins, P. K. Khopkar and J. N. Mathur, ibid.

Synergistic extraction of trivalent lanthanides by mixtures of N–benzoyl–N–phenyl hydroxylamine and neutral donors, J. N. Mathur and P. K. Khopkar, National Symp. on Solv. Extn., Madras, Nov. 19–20 (1985).

Nuclear chemistry research using medium energy heavy ion accelerators, Satya Prakash, DAE Radiochemistry & Radiation Chemistry Symp., Kanpur, Dec. 9–13 (1985).

Non–destructive assay of fissile materials, S. B. Manohar, ibid.

Fragment shell effect in low energy fission : Measurement of isotopic yield of technitium isotopes in thermal neutron induced fission of Pu–239, Alok Srivastava, A. Goswami, B. K. Srivastava, S. B. Manohar, Satya Prakash and M. V. Ramaniah, ibid.

Charge distribution study in the alpha particle induced fission of Th–232 : Effect of excitation energy, A. Ramaswami, B. K. Srivastava, S. M. Sahakundu, S. B. Manohar, Satya Prakash and M. V. Ramanish, ibid.

Fission fragment angular momentum : Evaluation of fragments scission point deformation, S. P. Dange, T. Datta, S. K. Das, Satya Prakash and M. V. Ramaniah, ibid.

Isotopic yield distribution of iodine in thermal neutron induced fission of Pu–241, A. V. R. Reddy, S. M. Deshmukh, S. B. Manohar, Satya Prakash and M. V. Mananiah, ibid.

Charge distribution in Pu–241 (N_{th},F) Determination of fractional cumulative yields of Sr–91, 92, H. Naik, S. P. Dange, T. Datta, Satya Prakash and M. V. Ramaniah, ibid.

Charge distribution studies in the reactor neutron induced fission of Np–237 : Fractional Cumulative yields of Te–134, I–135 and Xe–138, A. Ramaswami, S. S. Rattan, N. Chakravarty, R. J. Singh, S. B. Manohar and Satya Prakash, ibid.

Fractional cumulative yields of Ba–140, 142 and Ce–146 in the spontaneous fission of Cf–252, Alok Srivastava, B. K. Srivastava, A. G. C. Nair, S. B. Manohar, Satya Prakash and M. V. Ramaniah, ibid.

Isotopic yield distribution of iodine in the reactor neutron induced fission of Am–241, A. V. R. Reddy, S. M. Deshmukh, P. P. Burte, S. B. Manohar, Satya Prakash and M. V. Ramaniah. ibid.

Beta branching fraction of Cd–117 isomers and I. T. branching fraction of In–117m, A. G. C. Nair, N. Chakravarty, B. K. Srivastava, A. Goswami and Satya Prakash, ibid.

Charge particle induced nuclear reactions : Measurements of cross-section for Cm–244 (2n) Cf –246 reactions, B. S. Tomar, S. K. Das, S. M. Sahakundu, S. K. Saha, S. B. Manohar and Satya Prakash, ibid.

Alpha induced reaction of Bi-209, S. S. Rattan, R. J. Singh, S. M. Sahakundu and Satya Prakash, ibid.

Mass distribution at moderate energy : 38·5 MeV helium ion induced fission of Th–232, R. Guin, S. M. Sahakundu, S. B. Manohar, Satya Prakash and M. V. Ramaniah, ibid.

Interaction of charge transfer complexes with positron, T. Datta, S. P. Dange, H. Naik, P. K. Pujari, Satya Prakash and M. V. Ramaniah, ibid.

Perturbed angular correlation studies on Re–187 : Calculation of attenuation factors as a function of asymmetry, S. K. Das and B. S. Tomar, DAE ibid.

Polymerization studies on tungstates by perturbed angular correlation techniques, B. S. Tomar, S. K. Das and Satya Prakash, ibid.

Neutron multiplication correction : A new method, T. Datta,, S. P. Dange. H. Naik, Satya Prakash and M. V. Ramaniah, ibid.

Synergistic extraction of uranyl and plutonyl ions with phenyl–3–methyl–4–Benzoyl–pyrazolone–5 (HPMBP) and some aliphatic sulphoxides, S. A. Pai and M. S. Subramanian, ibid.

Extraction of plutonium from alkaline solutions by quaternary amine Aliquet–336. C. R. Mahajan, M. Ray, C. V. Karekar, V. K. Ran and P. R. Natarajan, ibid.

Adsorption of plutonium (IV) on alumina : Application to the recovery of plutonium from solutions containing phosphoric acid–nitric acid, V. K. Rao, M. Subba Rao, A. Kadam, I. C. Pius and P. R. Natarajan, ibid.

Extraction of Am(III) and Cm(III) by mixtures of N–benzoyl–N–phneyl hydroxylamine and tributylphosphate, J. N. Mathur and P. K. Khopkar, ibid.

Radiation effects in $SrSO_4$ doped with uranium and plutonium; An ESR and TSL study, T. K. Seshagiri, Mithleshkumar, R. M. Kadam, A. G. I. Dalvi and M. D. Sastry, ibid.

Tracer studies in recovery of rare earths from uranium–aluminium alloy, R. Sampathkumar, M. K. Bhide, A.G.I. Dalvi and M. D. Sastry, ibid.

Determination of nitrate in thorium, uranium and plutonium solutions, G. M. Nair and P. C. Kumar, Symp. on Fundamental and Applied Electrochemistry, Bombay, Dec. 4–6 (1985).

Assay of Uranium and plutonium in the same aliquot by potentiometric titration, G. M. Nair and P. C. Kumar, Symp. on Fundamental and Applied Electrochemistry, Bombay, Dec. 4–6 (1985).

Isotopic yield distribution of iodine in the reactor neutron induced fission of Np–237, A. V. R. Reddy, S. M. Deshmukh, P. P. Burte, S. B. Manohar, Satya Prakash and M. V. Ramaniah, DAE Nucl. Phys. Symp., Jaipur, Dec. 16–20 (1985).

Multinucleon emission from apha induced reaction of Au–197, N. Chakravarty, A. Ramaswami, R. J. Singh, S. S. Rattan, S. M. Sahakundu, Satya Prakash and M. V. Ramaniah, ibid.

Mass resolved fission product angular distribution in helium ion induced fission of Th–232, S. B. Manohar, A. Goswami, S. M. Sahakundu, T. Datta, Satya Prakash and M. V. Ramaniah, ibid.

Interaction of HBPHA with neutral donors and its effect on synergistic extraction of trivalent actinides and lanthanides, J. R. Mathur and P. K. Khopkar, Fifth Annual Conf. of Indian Council of Chemists, Dhanbad, Dec. 27–29 (1985).

Chelates of 1–phenyl–3–methyl–4–benzoyl–pyrazolone–5 with tetravalent thorium, uranium and plutonium, M. S. Nagar, P. B. Ruikar and M. S. Subramanian, ibid.

EPR investigation of stuctural phase transition in $(NH_4)_6\ Sb_4(SO_4)_3F_{12}$ (AASF), R. M. Kadam, Y. Babu, A. G. I. Dalvi and M. D. Sastry, Solid State Phys. Symp., Nagpur, Dec. 27–30 (1985).

Paramagnetic radical ions in $^{241}Am : CaSO_4$ and their role in thermally stimulated reactions : An EPR investigation, V. Natarajan, A G.I. Dalvi and M. D. Sastry, ibid.

Separation of ^{241} Am during Pu purification from mixtures of U, Pu and Ag, T. R. Bangia, B. A. Dhawala, V. R. Bhandiwad, M. D. Sastry and P. R. Natarajan, Nat. Symp. on Separation Techniques with Satellite Symp. on Solvent Extraction & Ion Exchange, Waltair, Jan. 9–11 (1986).

Chemical saparation of rare earths from uranium and plutonium for assay by ICP–ALS technique, A. G. Page, A. G. I. Dalvi, T. K. Seshagiri, Y. Babu, S. V. Godbole, M. D. Sastry and P. R. Natarajan, ibid.

Some studies on the cover gas in FBTR fuel elements, S. G. Kulkarni, G. A. Rama Rao, V. K. Manchanda, P. R. Natarajan and G. L. Goswami; Seminar on Fast Reactor Fuel Cycle, Kalpakkam, Feb. 10–12 (1986).

A new method for the dissolution and precise determination of uranium and plutonium in sintered uranium carbide, plutonium carbide and the mixed carbide, M. M. Charyulu, C. V. Karekar, V. K. Rao and P. R. Natarajan, ibid.

A gamma scanner for quality control of FBTR fuel elements, P. P. Burta, V. K. Chadda, J. K. Ghosh, G. K. Gubbi, A. V. Kathawate, S. Majumcar, S. B. Manohar, S. Murlidhar, S. N. Murthy, P. R. Natarajan, P. R. Roy, Satya Prakash and S. N. Seshadri,

Quality control of fast reactor fuels–Chemical aspects, P. R. Natarajan, ibid.

Electrothermal atomic absorption spectrometry for determination of trace metals in fast reactor fuels, B. M. Patel, N. Goyal, P. J. Purohit and A. R. Dhobale, ibid.

Trace metal assay of fast breeder test reactor fuel using direct reading spectrometer, A. G. Page, S. V. Godbole, S. K. Thulaesidas, Y. Babu, T. K. S. Giri, A.G.I. Dalvi and M. D. Sastry, ibid.

Analysis of moisture in nuclear fuels–A review, Mary Xavier, P. Venketaramana and P. R. Natarajan, BARC–841 (1985).

Semimicro determination of nitrogen in actinide compounds by Dumas method, M. S. Nagar, P. B. Ruikar and M. S. Subramanian, BARC–1299 (1986).

3. MATERIALS & MATERIALS SCIENCES

3·1 Materials

Heavy Water

A Heavy Water Upgrading Plant based on vacuum distillation process was successfully commissioned at MAPS, Kalpakkam and its performance has been excellent. Another Heavy Water Upgrading Plant was commissioned at RAPP, Kota. The Upgrading Plant at BARC functioned very satisfactorily and the heavy water which was degraded in the CIRUS and DHRUVA reactors was purified to reactor grade using this plant. Work on setting up of the Final Enrichment Plant for the Heavy Water Plants at Manuguru and Thal and on the Upgrading Plant at Narora made satisfactory progress.

Since hydrogen sulphide is an important feed material in the production of heavy water, work on setting up of a pilot plant for the production of high purity hydrogen sulphide through direct reaction of hydrogen with sulphur was set up. Based on the data collected through the successful operation of this plant, a commercial size plant is being designed. Encouraging results were obtained from basic research carried out in the identification of a suitable catalyst for water-hydrogen exchange studies which may also prove useful in removing tritium from heavy water. As a part of the preparation of heavy water standards for use in mass spectrometric analysis, "near O ppm", heavy water was produced by double distillation technique. The national survey for studying the variation in deuterium concentration in natural water sources was continued.

Rare Earths & Other Materials

The solvent extraction process for individual rare earth separation was further developed to produce samarium oxide of 99% purity starting with the concentrate of 60-70% purity. Similar R & D work aimed at production of gadolinium and yttrium of high purity has been taken up. In collaboration with Hindustan Zinc Ltd., a process for the production of high quality copper sulphate as a byproduct from their zinc plant residues was developed and a semi pilot plant has been set up for testing the process. If the process is successful, there is scope for an annual production of 500 tonnes of copper sulphate which has a ready demand from Hindustan Zinc Ltd. A process for recovery of cobalt from zinc residues was also developed and is awaiting tests at the plant by Hindustan Zinc Ltd. If it succeeds it will be the first indigenous production of cobalt. Hafnium, a nuclear poison which has to be removed from zirconium, has accumulated as a crude concentrate at NFC, Hyderabad. A process for extracting and purifying hafnium from this concentrate was developed and will be implemented at NFC, Hyderabad.

Work on the development of processes for the recovery of lithium from lepidolite ore, separation of thorium from uranium solution and purification of helium was continued. A high pressure unit based on condensation and cryogenic adsorption of nitrogen for separation from helium is being set up. Studies on separation of stable isotopes by various methods were continued. Nitric acid containing 40% nitrogen-15 was produced and was used in the preparation of N-15 compounds like urea, ammonium sulphate, diammonium phosphate, ammonium nitrophosphate, which were supplied to various institutions for agricultural research. Assistance was rendered to M/s. Rashtriya Chemicals & Fertilizers at Trombay in setting up a plant for large scale production of N-15 enriched nitric acid based on the process developed in BARC. Production of scintillation chemicals PPO and POPOP was continued to meet the increasing requirements of the nuclear power plants and various research organizations. Development work on the production of plastic scintillator materials was continued. In pursuance of the further development work on fluorine production technology, a 500 A fluorine cell with improved design parameters was commissioned. The performance of this cell was found to be satisfactory. The fluorine produced in the cells is being utilised for the preparation of sulphur hexafluoride and certain metal fluorides. Fabrication of a 1500 A fluorine cell is in progress.

3·2 Materials Sciences

Considerable advances were made in the pro-

grammes on boron carbide product development, molybdenum metallurgy, mineral processing, and alloy development.

A process for producing BORAL (a composite of boron carbide in an aluminium matrix) and boron carbide impregnated rubber sheets/sleeves has been well standardized. These materials were supplied to various users both within and outside DAE. Facilities for recovering molybdenum from its primary source, molysulphide, and from its secondary sources such as molybdenum scrap and lamp industry effluents were established. The alloy development programme principally oriented towards aluminium-zirconium and rare earth-silicon alloys were successfully scaled up. These alloys were supplied to Defence Organizations and Steel Plants. In the field of minerals, studies were made on ilmenite and sillimanite which are products of OSCOM. Laboratory processes to upgrade the ilmenite to synthetic rutile and to convert sillimanite into a granulated product for refractory brick manufacture are being developed. Subsequent to the very satisfactory performance of three prototype control blades for TAPS, fabrication of control blades was undertaken and one number has been delivered.

Substantial progress was made in the important areas of electrometallurgy and application of lasers in metallurgical research. Among the various electrometallurgical processes developed, extraction of lanthanum and cerium, electroless nickel plating of metallic and ceramic materials, electroplating of thin layers of aluminium from organic baths and electroplating of zircaloy billets deserve special mention. Electroless nickel plated alumina blocks made in BARC and installed in the recently commissioned MHD channel at BHEL at Trichy are performing well. Copper plated zircaloy billets are under evaluation with a view to replacing the elaborate procedure of mechanical cladding followed in the large scale fabrication of zircaloy. A 100W, continuous wave CO_2 laser facility was successfully operated and the possibility of its application in drilling, cutting threads, scribing on sintered alumina bodies, etc. is being explored.

The material evaluation programme has been mainly devoted to the study of corrosion of nuclear construction materials. Some of the important studies in this programme are assessment of fuel-clad and coolant-clad interactions, stress corrosion cracking behaviour of steam generator tube materials and special steels chosen for use as in-core material in the BWR at Tarapur. In the course of studies on hydrogen embrittlement of zirconium-niobium alloy coolant tubes, a new technique was developed for charging hydrogen into the alloy. Compatibility studies were also carried out on copper, nickel based alloys and titanium alloys for their use in saline water environment encountered in power reactors and desalination plants.

Investigations pertaining to the behaviour of alloys in different thermal, chemical and radiation environments were carried out with special reference to structural materials used in nuclear power plants and heavy water plants. These included studies on changes in microstructures and mechanical properties of nickel based alloys in high temperature service, steels in hydrogen environments, and zircaloy and nuclear steels under cyclic loading.

Zirconium-niobium alloy, the pressure tube material for the latest generation pressurized heavy water reactors, was systematically studied in collaboration with Nuclear Fuel Complex with a view to optimizing the fabrication parameters and to achieve important in-reactor property requirements. An in-pile creep facility was fabricated for installation in DHRUVA with a view to generating data on Zr-Nb and other alloys which will be useful in the construction of future PHWRs. Experiments are also planned to generate quick data on in-pile creep on these materials. Different methods of solid state bonding of zircaloy with zircaloy as well as with stainless steel were attempted and the mechanism of bonding was studied.

Rapid solidification was employed in preparing a variety of metallic glasses, microcrystalline nickel based superalloys and quasicrystalline materials.

Shape memory alloys like nickel-titanium and

copper-zinc-aluminium were developed and a working model to demonstrate the principle of a solid state heat engine was constructed and also exhibited.

Work on the development of twisted niobium-titanium superconductor wires was continued. 50 kg of 45-filament wire of 0·5 mm diameter was fabricated and supplied for making magnets for low temperature physics experiments.

In view of their promise as a potential new class of ferro-electric materials, several vanadium oxyfluorides were investigated to locate the phase transitions as well as to obtain the enthalpies and also to define their thermal stability range. A notable accomplishment is the setting up of a computerised crystallographic data base system.

3·3 Process Technology

Desalination

Fabrication work related to the setting up of 425 m^3/day Multi-Stage Flash Desalination plant has been completed. Erection of equipment and piping is in progress. The plant is expected to be commissioned by Dec, 1986. Erection work on the 30 m^3/day ship-borne desalination plant has been completed and trial runs will be started shortly. Process design of the 250 m^3/day VTE-MSF (Vertical Tube Evaporation-Multi Stage Flash) process desalination plant has been completed and machinical design is in progress. R & D work related to the development of materials suitable for sea water services and for advanced heat transfer tubes was carried out.

Two reverse osmosis desalination plants of 10 m^3/day capacity (based on 8 hr/day operation) were set up in Gujarat and Andhra Pradesh. These plants supply drinking water to the villagers from the only available source of brackish water. Performance data obtained from the reverse osmosis demonstration unit at the Ennore Thermal Power Station in Tamil Nadu indicated that combined reverse osmosis and ion- exchange process is suitable for economical production of boiler grade water for thermal power stations. Small reverse osmosis units of 30 lit/hour capacity, suitable for use as portable fresh drinking water supply units in canteens, hospitals, etc. were assembled and demonstrated at various exhibitions. R & D work for development of new membranes for reverse osmosis process was continued.

Hydrogen Production

All the civil and air handling work for the 70 kg/day Electrolytic Hydrogen Plant was completed. Work is in progress on the installation of electrical, process and mechanical equipment. Technology for electrolytic production of 3 kg/day hydrogen was tansferred to M/s. Gujarat Machinery Ltd. on a non-exclusive basis.

Tin Pilot Plant

Based on the process technology developed in BARC,a pilot Tin Extraction Plant was set up at Raipur, Madhya Pradesh, in collaboration with the M.P. State Mining Corporation. The plant was formally inaugurated by the Chief Minister of Madhya Pradesh on June 14, 1985. Plans are on hand to extend the necessary technical help to M.P. State Mining Corporation for setting up large scale plants and preliminary technical report is already prepared.

Others

The significant achievements in the development of new processes and products were 50 g scale preparation of gallium phosphide– a high technology electronics raw material; demonstration of high temperature catalytic activity of a new hydrophobic catalyst for deuterium exchange in liquid water and scaled up preparation of coumarin laser dyes.

Beryllium Technology

Vacuum hot pressed beryllium blocks were produced in kilogram quantities from Indian beryl ore after streamlining process parameters, and components of intricate shape were machined for use by Department of Space. Large quantities of copper beryllium alloy ingots for further fabrication into the requisite shapes and some lengths of Cu-Be strips were made for use in electronics industry.

Publications

K.V.S.R. Apparao and N.K. Sahoo, "Design and development of thin films dielectric beam combiner", *Bull. Mater. Science* (in press)

R.H. Iyer, "Nuclear Materials Accounting (Invited Talk)", Proceedings of the DAE Symposium on Radiochemistry and Radiation Chemistry", Paper No. S-14, Page 216, I.I.T., Kanpur, Dec. 9-13, 1985

P.R. Vaidya, B. Ghosh and R. Krishnan, "Studies on relief in X-radiography", *Material Evalution* **43** (1985) 1443

P.B. Srivastava, N. Venkatramani, V.K. Rohatgi, M.K. Totlani and C.K. Mittal, "Electroless nickel deposition on ceramic and copper surfaces", *Metal Finishing* **83(2)** (1985) 65

P.B. Srivastava, Y.N. Rao, N.Venkatramani, V.K.Rohatgi and C.K.Mittal,"Ni-B and Ni-P alloy coatings on ceramic and metal substrate by electroless technique", Int.Conf.on Electroplating & Electroforming,Bangalore,1986.

V. Ramachandhran and B.M. Misra, "Studies on electrodialytic separation of radionuclides from effluent streams". *Sep. Sci. & Tech* **7–8** (1985) 623

V. Ramachandhran, B.M. Misra and M.P.S. Ramani, "Some aspects of treatment of radioactive liquid effluents using RO and ED", *BARC/I–845*

S. Prabhakar and B.M. Misra, "Studies on structural, kinetic and thermodynamic parameters of cellulose acetate membranes", *J. Memb. Sci.* (in press)

S. Prabhakar and B.M. Misra, "Relative transport of water (H_2O) and tritiated water (HTO) across cellulose acetate membranes", *Radiochimica Acta* (in press)

R.N. Patra, B.M. Misra and M.P.S. Ramani, "Reverse Osmosis (RO) process for boiler feed make up water at Dhuvaran thermal power station", Indian Chemical Manufacturers (in press)

V. Ramachandhran and B.M. Misra, "Studies on the radiation stability of ion exchange membranes", *J. Appl. Poly. Sci.* (in press)

S. Prabhakar, B.M. Misra and M.P.S. Ramani, "Separation of tritium from aqueous streams using membranes", Radiochemistry and Radiation Chemistry Symp. IIT Kanpur, 1985.

V. Ramachandhran and B.M. Misra, "Effect of γ-irradiation on PSA membranes", *ibid.*

V.K. Srivastava, A.K. Saxena and M.P.S. Ramani, "High pressure steam distillation process for the recovery and purification of phosphorus", *Indian Journal of Technology* (in press)

D. Goswami, A.K. Saxena and M.P.S. Ramani, "Europium hexaboride: A case study of control material for fast breeder reactors", *BARC/I–836*

V.K. Srivastava, A.K. Saxena, M.P.S. Ramani, "Operating experience with indigenous low grade raw materials in Phosphorus Pilot Plant at Trombay", *BARC/I–834*

A.K. Saxena and M.P.S. Ramani, "Reduction of energy needs in phosphorus production", Seminar on Energy Conservation in Chemical Process Industries, Roorkee, July 1985.

V.K. Srivastava, A.K. Saxena and M.P.S. Ramani, "Use of low grade silicious rock phosphate in electrothermal process for the production of elemental phosphorus", *Indian Journal of Technology* (in press)

V.K. Srivastava, A.K. Saxena and M.P.S. Ramani, "Safety aspects in the design and operation of Phosphorus Plant", 38th Annual Session of IIChE Congress, Calcutta, Dec. 1985.

P.K. Tewari, R.K. Verma, M.P.S. Ramani, S.P. Mahajan, "Studies on Nucleate Boiling of Sodium Chloride Solutions at Atmospheric and Sub-Atmospheric Pressures," *Desalination* **52** (1985), 335-344

P.K. Tewari, P.K. Ghosh, R.K. Verma and M.P.S. Ramani, "Analysis of Dual Purpose Power-cum-Desalination Plants", Seminar on Energy Conservation in Process Industries, Institute of Engineers, Roorkee, July 1-2, 1985.

P.K. Tewari, R.K. Verma, M.P.S. Ramani and S.P. Mahajan, "Effect of Surface Roughness and Polymeric Additives on Nucleate Boiling at Sub-atmospheric Pressures", *Heat & Mass Transfer* (in press).

P.K. Tewari, R.K. Verma, M.P.S. Ramani and S.P. Mahajan, "Combined Effect of Surface Roughness and Polymeric Additives on Nucleate Boiling at Low Heat Flux", VIIIth National Heat & Mass Transfer Conference, Vishakapatnam, Dec. 29-31, 1985.

M. Imam, M.S. Hanra, R.K. Verma and M.P.S. Ramani, "Multi-stage Flash Desalination Process : Past Experience, Present Work and Future Plans, Bhabha Atomic Research Centre", 38th Annual Session of IIChE, Calcutta, Dec. 17- 20, 1985.

M.P.S. Ramani, "Electrolytic Hydrogen Production", *Progress in Hydrogen Energy*, Ed. R.P. Dahiya, D. Riedel Publishing Co. 1985.

M.G. Nayar, "Hydrogen as a Future Source of Energy", International Conf. on Energy–Conventional and Alternative Sources, Hotel Oberoi Towers, Bombay, Jan.12, 1985.

M.G. Nayar, M.P.S. Ramani, D.K. Jain, P. Raghunathan and S.K. Mitra, "Hydrogen Powered Engines vs Petrol Driven Engines - A comparative technical and economic asessment", *BARC/I–839*

S.K. Mitra, P. Raghunathan, D.K. Jain and M.G. Nayar, "Comparative Cost Estimates for Advanced Water Electrolysis Plants", *BARC/1-838*

"Advanced Electrolyser for Small Scale Hydrogen/Oxygen Applications",First National Conference on Electro-Chemicals, Sahupuram, Aug. 16 – 17, 1985.

P. Ragunathan, M.G. Nayar and M.P.S. Ramani, "Porous Nickel Electrodes by Alloy Electrodeposition Technique" 'Industrial Metal Finishing' Symposium, Karaikudi, July 18-20, 1985.

T.S. Krishnan, R.S. Babu and C.K. Gupta, "Studies on Preparation of ZrO_2 from Indian Zircon", Accepted for presentation in the Conference 'Zirconia-86' Tokyo, September 9-11, 1986.

S.P. Biswas, T.S. Krishnan and C.K. Gupta, "Recovery of Silver from the Silver Residue from IRE", Report Communicated (1985)

J.C. Sehra, "Fused Salt Electrolysis - A Note for Preparation of Refractory Metals" (Invited Talk), Symposium on Fundamentals of Electro-chemistry, SAEST, Bombay Chapter, Dec. 1985.

I.G. Sharma and J.C. Sehra, "Electro-refining of Titanium Scrap - Cathode Materials and Bath Studies", *ibid.*

K.B. Gaonkar, P.K. Chauhan and H.S. Gadiyar, "Oxidation and Corrosion Behaviour of Magnetite-Coated Carbon Steel after Chemical Cleaning" *J. Electrochem. Soc. of India* (1985)

H.S. Gadiyar, P.K. Chauhan and A. Sharma, "Cooling Water Treatment, Principles and Current Practices - An Overview", *COSWAC*(1985)

D.D. Upadhyaya, P.Y. Dalvi, A.K. Kulkarni and S.V.K. Rao, "Toughened Ceramics - Recent Trends and Status", Symp. Emerging Frontiers in Ceramics, BHU, Varanasi, Oct. 11-13, 1985.

I.G. Sharma and T.K. Mukherjee, "A Study on Purification of Metallurgical Grade Silicon by Molten Salt Electro-refining", *Met. Trans.*(1985)

J.M. Juneja and T.K. Mukherjee, "A Study on Purification of Metallurgical Grade Silicon", *Hydrometallurgy* (1985)

J.M. Juneja, G.N.K. Iyengar and K.P. Abraham, "Thermodynamic Properties of Liquid Mg-cu Alloys by Vapour Pressure Measurements using Boiling Point Method", *J. Chem. Thermodynamics* (1985, in print).

J.M. Juneja, K.P. Abraham and G.N.K. Iyengar, "Thermodynamic Properties of Liquid Mg-Al Alloys by Vapour Pressure Measurements using Boiling Point Method", *Scripta Metallurgica* (1985, in print).

J.M. Juneja, K.P. Abraham and G.N.K. Iyengar, "Measurement of Vapour Pressure of Liquid Magnesium by the Boiling Point Method", *Trans. IIM* (1985, in print).

A.K. Grover, A.L. Pappachan, Sohan Singh and H.S. Gadiyar, "Electroforming of thin walled nickel tubes", *J. Electrochem Soc. India* **34**(*1*) (1985).

H.S. Gadiyar and P.K. Chauhan, "Corrosion and Magnetite Growth on Carbon Steels during Hot Conditioning Treatment - An Analysis", *BARC/I-849* (1985)

Sohan Singh, A.L. Pappachan and H.S. Gadiyar, "Electroproduction of Cerium and its Alloys," *J. Less Common Metals* (1985, in print).

S.V. Phadnis, J.V. Joshi and H.S. Gadiyar, "Break-down of Passivity of Zircaloy-2 in 5% NaCl Solution", Annual Technical Meeting of the Indian Institute of Metals, Jamshedpur, Nov. 14-17, 1985.

Sohan Singh, M. Karuppan Chetty, J.M. Junena, J.C. Sehra and C.K. Gupta, "Studies on the Processing of Molybdenite Concentrate by Lime Roasting", *ibid.*

P.R. Menon, P.P. Shukla and T.K. Mukherjee, "A Study on Recovery and Reduction of Calcium Molybdate", *ibid.*

A. Bose and P.K. De, "The Influence of Prior Cold Work on the Degree of Sensitization of AISI 304 SS as Measured by EPR Method and its Comparison with ASTM A-262-E", *Corrosion Nace* (1985, in print).

S.K. Ghosal and P.K. De, "Environment induced cracking of zircaloy-2 fuel cladding tube", *BARC–1276* (1985)

D.D. Upadhyaya, "Lattice defect structure and mass transport processes in insulating solids", 1st National Seminar on Defects in Insulating Solids, RIT, Jamshedpur, Nov. 6-8 1985.

G.C. Palit and H.S. Gadiyar, "Pitting Corrosion of Zirconium in Chloride Solution", *Corrosion Journal Nace* (1985, in print).

J.B. Gnanamoorthy, K.S. Krishna Rao, S.V. Narasimhan, A.C. Shah, P. Muralidharan, E.G.A. Namboodiri and K.B. Goankar, "Evaluation of Hot-conditioning of the Primary Heat Transport Systems of MAPP-II", Report submitted (1985).

T.K. Mukherjee, P.R. Menon, P.P. Shukla and C.K. Gupta, "Chloridising Roasting Process for a Complex Sulphide Concentrate", *J. Metals* (June, 1985) 28.

D.K. Bose, O.K.Mehra and C.K. Gupta, "Preparation of Re-Si-Fe alloy by metallothermic reduction", *J. Less Common Metals* **110**(*2*) (1985) 239

Chintamani, N. Saratchandran, P. Pande, A.K. Taneja and J.C. Sehra, "Recycling of off-grade zircaloy scrap using a molten salt electro-refining process", 7th Int. Conf. on Zirconium in Nuclear Industry, Strasbrong, France, June 24-27, 1985.

K.N. Adhe and P.R. Shibad, "Corrosion Behaviour of SS 430 in Nitric Acid Environments", Annual Technical Meeting of the Electro-Chemical Society of India, Bangalore, June 1985.

K.B. Gaonkar and H.S. Gadiyar, "Corrosion of magnetite coated carbon steel-Effect of descaling treatment", *ibid.*

M.K. Totlani, "Functional and Decorative Plated Coatings", Seminar on Surface Finishes, IIT Bombay, March 27-28, 1985.

P.R. Singh, P.K. Chauhan and H.S. Gadiyar, "Corrosion - Fundamental Aspects", Workshop on Electrochemistry, IIS, Bangalore, Feb. 25 - March 1, 1985.

M.K. Totlani, "Electroless Deposition of Metals", Short Term Course on Coating Technology, COAT-TECH-85, BARC, Bombay, Jan. 23-25, 1985.

H.S. Gadiyar and A.K. Grover, "Evaluation of Coatings", *ibid.*

P.Y. Dalvi and A.K. Kulkarni, "Development of High Temperature Lab-Type Gas Fired Furnace", Local Chapter Meeting of the Ind. Cer. Soc., Bangalore, Jan. 1985.

J.C. Sehara, P.L. Vijay, C.V. Sundaram and R. Mallikarjunan, "Studies on the separation of hafnium from zirconium by fused salt electrolysis", Proceedings of the Nat. Conf. on Progress in Metallurgical Research Fundamental and Applied Aspects, Kanpur, Feb. 1985.

V.D. Shah, M.G. Rajadhyaksha, R.H. Rakhasia, R.S. Babu and S. Saha, "Halide Metallurgy in Beryllium Extraction", *ibid.*

D.K. Bose et al., "Some thermochemical studies of cesium uranate, molybdate and chromate", *J. Nucl. Materials* **130** (1985) 122.

P.K. Chauhan and H.S. Gadiyar, "An XPS study of the corrosion of Cu-10Ni alloy in unpolluted and polluted sea water - effect of $FeSO_4$ additions", *Corrosion Science* **25** (1985) 55. Discussion on the paper : *ibid.* **25** (1985) 1193

P.K. Chauhan, H.S. Gadiyar and R. Krishnan, "XPS for surface film analysis in corrosion research, *Pramana* **24** (1985) 383

P.Y. Dalvi and A.K. Kulkarni, "Strength of CaO-partially stabilized zirconia" 49th Annual Session of the Indian Ceramic Society, Hyderabad, March 1985.

P.K. De, S.K. Ghosal and H.S. Gadiyar, "Influence of Microstructure on Stress Corrosion Cracking Resistance of Alloy 600 in 315°C Water", ICMS-85 Calcutta, Feb. 1985.

S.K. Ghosal, P.K. De and H.S. Gadiyar, "An Investigation of Pitting Behaviour of a Duplex Stainless Steel", *ibid.*

A.K. Chokkera, N.S.D. Elayathu and H.S. Gadiyar, "Magnetite formation on carbon steel in high temperature water systems", *ibid.*

H.S. Gadiyar, "Corrosion and hydriding of fuel cladding materials", in *Survey on Investigation of Fuel Element Cladding Interaction with Water Coolant in Power Reactors*, IAEA Publication, *IAEA-TEC DOC-356*, 1985

P.K. Chauhan, K.B. Gaonkar and H.S. Gadiyar, "Ellipsometric - electrochemical study of the passive films formed on stainless steels in 2N nitric acid", *J. Ele. Chem. Soc. of India* **34** (*3*) (1985) 164

P.K. De and D.L. Roy, "Thermokinetic Model of Stress Corrosion Cracking", ICMS 85, Calcutta, Feb. 1985

P.R. Shibad and K.N. Adhe, "Effect of Addition Agents on the Corrosion Behaviour of Copper Based Alloys in Salt Water", *Trans IIM* **38** (*1*) (Feb 85) 17.

K.N. Adhe and P.R. Shibad, "Adsorption of acridine on aluminium based alloys in dilute hydrochloric acid solutions - Kinetic and thermodynamic parameters", *JECS India* **34** (*2*) (April 85) 138

M.K. Totlani, "Plated Hard Surface Coatings", Intensive Course on Surface Hardening, ASM India Chapter, Nov. 21-23, 1985

T.S. Krishnan and C.K. Gupta, "Application and Process Metallurgy Aspects of Niobium, Tantalum and Hafnium", ASTM Special Technical Publication devoted to papers included in the 4th Symp. on Titanium and Uranium in Industrial Applications (1985, in print).

D.K. Bose, K.U. Nair and C.K. Gupta, "Studies on the Production of Boron Carbide", *J. High Temperature Materials and Processes* (1985, in print)

T.K. Mukherjee and C.K. Gupta, "Reclamation of molybdenium powder from its scrap", 11th Plancee Seminar Proceedings, Vol. 1, Ed. Hubert Bildstin and Hugo M Ortner, *RM35* (1985)325.

C.K. Gupta, "Cermets", *Science Today* (Dec. 1985) 43.

P.Y. Dalvi and D.D. Upadhyaya, "Microstructure and Property Control in Mg-PSZ through Powder Processing", Accepted for presentation in the conference 'Zirconia-86' Tokyo, Sept. 9-11, 1986.

G.P. Kothial, M.K. Rajpurkar and Ram Prasad, "Measurement of thermophysical properties of single crystals of germanium", Symposium on Crystal Growth, Calcutta, Jan. 29-31, 1986.

R. Bhat, S.K. Roy and S.V.K. Rao, "Sintering Studies in Magnesia-Monticellite system", Annual Session of the Indian Cer. Soc., Feb. 11-13, 1986. Calcutta.

Ram Prasad, A.K. Gulnar and S.V.K. Rao, "Sintering behaviour and electrical conductivity of Ceria-stabilised zirconia", *ibid.*

P.K. Agnihotri, "Influence of minor additions of Cr_2O_3 and Nb_2O_5 on the densification and grain development of UO_2", *ibid.*

D.D. Upadhyaya and C.M. Sunta, "Defect interactions and TL behaviour in Thoria", *J. Nucl. Mat.* **127** (1985) 137.

R.Krishnan and D.D. Upadhyaya, "Defect structure using positron annihilation spectroscopy", *Pramana* **24** (*1 & 2*) (1985) 351.

J.C. Sehra, P.L. Vijay, C.V. Sundaram and R. Mallikarjunan, "Electrometallurgical process for the recycling of zircaloy scrap", 11th Plancee Seminar Proceedings, Vol. 1, Ed. Hubert Bildstin and Hugo M Ortner, *RM 35* (1985).

B.K. Shah, S.N. Malhottra and R.D. Angol, "Monitoring of Intergranular Corrosion in Austenitic Steel AISI 304 by Eddy Current Test Method", IIM Annual Technical Meeting, Jamshedpur, Nov. 14-17, 1985.

V.M. Bhole, P.G. Kulkarni and R. Vijayaraghavan, "Quality Assurance and Reliability of Power Plant Equipment by Multiparameter Eddy Current Testing", Symposium organised by ISNDT, Bombay, February 85.

P.R. Vaidya and L. Venkataraman, "Non-destructive examination of electron beam weld in Dhruva reactor calandria", Symposium on recent development in welding metallurgy and processes, Bombay, February 1985.

L. Venkataraman, "Nondestructive testing and flaw characterization", *Quality Evaluation* **5** (*3*) (1985).

A.K. Sinha, B.K. Shah and P.G. Kulkarni, "Monitoring of oxide layer thickness on Zircaloy-2 eddy current method", Symposium on Metallography and NDT: Interactions in Materials Evaluation, Bombay, February 1986

L. Venkataraman and A.R. Biswas, "Metallography as an aid to UT interpretation", *ibid.*

A.R. Biswas and P.R. Vaidya, "Interaction between Radiography/ Metallography for explanation of non-relevant indication in radiography", *ibid.*

P.R. Vaidya, B. Ghosh, R. Krishnan, "Study of relief in X-ray radiography", *Materials Evaluation* **43** (October 1985).

M.M. Thomare, U.S.P. Singh and R. Vijayaraghavan, "Nitriding and its applications to stainless steel components", 'Coating Techonology-85'–a short term course held at BARC during January 23-25, 1985.

S.P. Singh, U.S.P. Singh and M.M. Thomare, "Melting Experience with MTR Uranium Ingots", 39th Annual Technical Meeting, IIM, Jamshedpur, November 14-17, 1985.

S.P. Singh, S.V. Paibhale, V.G. Date and R. Vijayaraghavan, "Fabrication of silver - nickel composite", *Tans. PMAI* **12** (September 1985).

M.K. Mallik, M.M. Thomare and R. Vijayaraghavan, "indigenous development and fabrication of Nb-Ti superconducting wires", Workshop on Physics, Metallurgy and Technology of SC Matterials, IGCAR, Kalpakkam, January 22-25, 1986.

N.G. Dutta, M.A. Mankame, P.G. Kulkarni, R. Vijayaraghavan and K. Balaramamoorthy, "Experience in the Application of IAEA QA Code and Guides in the Manufacture of Nuclear Reactor Components", Proc. Int. Symp. on Safety Codes and Guides (NUSS) in the Light of Current Safety Issues, IAEA (1985)

P.B. Desai and R. Vijayaraghavan, "A case study on the Welding of Zircaloy Appendages on to the Tubes", National Welding Seminar, BARC, February 1985.

V.G. Date and R. Vijayaraghavan, "Indigenous Fabrication of Control Blades", *Nuclear India* **23** (*2*) (1984).

R. Vijayaraghavan, "State of Art: Superconducting Materials", 3rd All India EHV Forum, New Delhi, April 1985.

F.P. Saldanha, K.R. Gurumurthy, V.C. Date and M.C. Saxena, "Development of Fabrication of Superconducting Wires by P/M Techniques", PMAI, Jamshedpur, February 1985.

P.B. Desai, "Preparation and Characteristic of Be Coating", Symposium on Met. Coatings, San Diego, USA.

P.N. Talcherkar, K.R. Gurumurthy and V.G. Date, "Oxide dispersion strengthened copper", 12th Annual Technical Conference, Hyderabad, March 15-16, 1986.

S. Ramakrishana, M.C. Saxena, Girish Chandra, "Tc and resistivity studies on Superconducting U_6Fe compound", Int. Conf. on Cryogenics and Low Temp. Physics, Bangalore, December 1985.

4. LIFE SCIENCES

4·1 Molecular Biology & Agriculture

A DNA repair gene isolated from a species of bacteria *(Haemophilus influenzae)* was cloned. This DNA clone when added to repair deficient cells of the same bacterium made them as resistant to the action of ultraviolet light as the normal cells.

A small plasmid with a molecular weight as low as 6×10^6 was isolated for the first time from the bacterium *Rhizobium meliloti*. This plasmid could be detected physically but its presence could not be monitored genetically. DNA of this plasmid has now been loned in *E. coli* with another plasmid which contains genetic markers and can now thus be tracked genetically.

Streptomycetes are economically important micro-organisms for production of several antibiotics. A temperate phage (virus) isolated from *Streptomyces* can infect several species of this genus and can bring about heritable changes in the host following integration of phage DNA.

In the absence of sodium, nitrogen fixation does not occur in cyanobacteria. Presence of sodium ensures adequate levels of nucleoside phosphates which seem essential for processing nitrogenase to convert nitrogen to ammonia. Field experiments demonstrated drastic fluctuations in the type and number of cyanobacteria present during the monsoon rice crop season. Two strains of cyanobacteria were found to be efficient in nitrogen fixation under monsoon climate.

Transposon 9 (Tn9), which is one of the mobile elements in bacterium *E. coli* and carries a gene for resistance to antibiotic chloramphenicol, can increase or decrease the number of its copies depending on the genetic background of the host cells. Six new genes were implicated in the amplification and one in deamplification of Tn 9.

Favourable effect on grain yield in barley by foliar sprays of growth regulators at flag leaf senescence initiation stage was found to be due to higher contribution from 5th onward secondary tillers. A concentration-dependent antagonistic interaction of morphactin with gibberellin was noted in barley.

A new method for efficient fusion of yeast protoplasts using electrical fields was devised. In many respects this is superior to the conventional polyethyleneglycol method.

The effect of a common anti-cancer drug, melphalan, on a solid malignant tumour in mice was found to be considerably enhanced when it was given in combination with trimeprazine, which is a potent sensitiser for tumour cure by radiations and hyperthermia.

4·2 Biochemistry

An international collaborative study was undertaken to evaluate the germinal mutagenic activity of two unknown carcinogens.

Serum samples collected from 35 MIC-affected persons were analysed for any possible alterations in their protein pattern. About 17 protein bands were obtained and general pattern was comparable to that of the healthy samples. However, in some MIC-samples, a distinct extra protein band was obtained in the globulin region.

Efforts were made to analyse structures of DNA segments having crucial regulatory functions. Low doses of ultraviolet radiation were found to inflict injury preferentially on segments of yeast mitochondrial DNA involved in initiation of mitochondrial DNA replication and transcription. Structure-function relationships of a number of proteins and enzymes having important roles in cell metabolism and regulation are being elucidated. Studies on carbohydrate metabolism in halobacteria revealed that normal pathway of glucose breakdown is replaced by a modified pathway. A number of model systems were studied to understand chemobiological interactions and their roles in drug action and toxicity. Among the studies carried out are action of the betablocker drug propranalol in regulating cardiac functions, action of the antidepressant drug imipramine on brain proteins and perturbations in biomembrane structures brought about by the leprosy drug, dapsone. Investigations on the drug metabolising enzymes and their induction by normal metabolites were continued. It was demonstrated that normal metabolites such as nicotinamide, methionine, and reduced glutathione, could effectively enhance activities of the

drug metabolising enzymes in livers of normal and tumour-bearing animals. This phenomenon could have relevance to cancer- chemotherapy.

Simple test systems based on covalent interactions with DNA were developed with a view to identifying substances that may have potential to antagonise carcinogenic propensities of certain chemicals. Promising results were obtained with some natural and synthetic components, viz., vitamin-A, vitamin-B_2, and their physiological derivatives, flavonoids, copper, and synthetic antioxidants. Studies are being carried out to develop newer diagnostic methods based on biochemical principles for certain disorders like cancer and cardiac malfuntions. Oxalate oxidase was purified from plant sources including banana peel with the aim of using it in enzyme therapy for kidney stones. Studies on metabolism and elimination of radionuclides, viz., radium, thorium and strontium in animals are being continued.

4·3 Bio-Organic Chemistry & Biotechnology

Research pertaining to the propagation of economic as well as crop plants through tissue and cell cultures as well as the isolation of bioactive compounds from plant sources were continued.

Embryogenic tissue cultures of sandalwood were maintained and periodically plantlets were derived from them. As a part of technology transfer 48 test tube raised plants of sandalwood were supplied to Sandal Research Centre, Bangalore and 85 in vitro derived plants of mulberry were given for field trials to the Central Sericultural Research & Training Institute, Mysore. Investigations on the multiplication of oil palm through tissue cultures were intensified. Methods for mass cultivation of plant cells in bio-reactors were standardised. Cell suspensions of certain plants were successfully grown in seven litre capacity air-lift bio-reactors. A two-staged cultivation of some of the plant cells in bio-reactors resulted in significantly higher production of ajmalicine and serpentine, which are used to treat human circulatory disorders.

Actue toxicity evaluation of Tylophora alkaloid extract was completed and the drug was found to be safe. This alkaloid extract was found to be antimutagenic in experimental models. Certain chemicals useful in the treatment of diseases such as liver cirrhosis and jaundice were extracted from some of the commonly occuring plants.

Work on scaling up the process for continuous hydrolysis of sucrose to produce syrups containing fructose and glucose using immobilized yeast cells was started. Ureolytic organisms which tolerate high concentration of urea and ammonia were isolated. A yeast variety rich in D-amino acid oxidase and catalase was immobilized in polyacrylamide beads using gamma rays.

Totapuri mango pulp was found to contain limiting amounts of pyruvate and pyruvate decarboxylase to generate aroma. The incorporation of exogenous sodium pyruvate and yeast pyruvate decarboxylase increased aroma intensity in Totapuri pulp.

4·4 Nuclear Agriculture

Experiments carried out during the year generated new materials and information useful for genetic improvement of crop plants, enhancing the efficiency of fertilizers and micronutrients, and understanding the environmental impact of agro-chemicals and organic manures.

The Ministry of Agriculture, Government of India, released varieties of pigeon pea, black gram and groundnut developed in BARC for commercial cultivation. Kerala State Seed Committee released two groundnut varieties for cultivation. In the widely grown bread wheat variety, Kalyansona, two alien genes for stem rust resistance from rye were incorporated. These lines have shown a high degree of resistance to all the races of stem rust prevalent in India.

New low cost nitrophosphate fertilizers (ENPEX) developed by Projects and Development India Ltd., Sindhri, were evaluated. In general, ENPEX fertilizers were found to be equal or superior to the currently used phosphatic fertilizers diammonium orthophosphate (DAP) and ammonium nitrate phosphates (ANP) in two soil types. Iron is an important micronutrient required by

many plants, and non-availability of iron causes chlorosis and reduces yield. A chemical was identified which when supplied to chlorotic sorghum makes iron available to the plants which turn green within 24 hours of application.

Application of pesticide lindane to crop plants resulted in the formation of unextractable residues in soil. Investigations carried out suggest that bound residues of lindane may not be of any toxicological significance. Higher cadmium levels were found in plants grown in soils manured with sewage sludge and city compost containing cadmium indicating that caution is needed in applying sludge and compost containing even low levels of cadmium to farm lands.

4·5 Pest Control

It was found that contrary to Hopkins hypothesis, spotted bollworm females do not show any preference for oviposition to the host plant on which its larvae were reared. By selective screening and breeding through 22 generations, a population of the khapra beetle with considerably reduced male response to the female sex pheromone was obtained. The pheromone secreted by the females of the selected population was found qualitatively different from that of the parent population. Treatment of potatoes with a microbial insecticide dust gave protection from the tuber moth damage for more than three months. A microsporidian isolated from the American Cotton Bollworm was also found pathogenic to the tobacco leaf eating caterpillar.

Several plant extracts and synthesised compounds were tested for their insecticidal, hormonal and antifeedant action in insects. A few of these compounds were identified for detailed work. Sex phermones of patato tuber worm moth, black cut worm, and Crematogaster ants were synthesised.

4·6 Food Technology

Research on the application of radiation to the preservation of a variety of food materials was continued. A delay in the time of irradiation following harvest was found to result in a transient stimulation of sprouting in "Rabi" onions during storage. Preliminary results indicated that holding irradiated onions at temperatures above 30°C for 20 to 30 days prior to transferring to lower temperatures significantly reduced the radiation induced stimulation of sprouting. Biochemical basis for the apparent susceptibility of gamma-irradiated potatoes to soft rot was investigated with reference to phenyl propanoid metabolism. Experiments have shown that irradiated potatoes treated with a species of bacteria (Bacillus thuringiensis) could cause reduction in spoilage by soft rot organisms. The mechanism of protein degradation and the resultant spoilage processes was studied in fish skeletal muscle and other tissues. A method to differentiate a fresh fish from the stored one is being developed. Exposure to gamma radiation effectively sterilised some of the common Indian spices without any deleterious effects on the quality. The method is effective in eliminating microbes in prepacked ground spices obtained from local markets which are found to be highly contaminated with bacteria and fungi. The volatile oils from the leaves, stalks and matured green berries of pepper were isolated and analysed. Methods to control aflatoxin producing fungi in groundnuts and maize were developed. Detoxification of lipopolysacharides from common pathogens in flesh foods was accomplished by irradiation at 3·0 Mrad. Alphonso mangoes ripened at a temperature above 30°C develop brown discoloration of the skin. However, ripening at 20°C was found to avoid such discolouration in ripe fruits. These fruits could then be stored for about 2 weeks at 10°C. Green Alphonso mangoes stored for 30 days at 10°C and subsequently ripened at 30 to 35°C could be held for a further period of 2 weeks at 10°C without any damage.

4·7 Radiation Medicine

Animal models for cirrhosis of the liver and parasitic diseases were standardised. Animal models for brain tumours were developed and the usefulness of various radiopharmaceuticals as imaging agents is being evaluated.

New methods are being developed for the evaluation of certain thyroid hormones (free T_3 and free T_4) which

will be useful in day-to-day clinical assessment of thyroid diseases as well as in experimentally induced disorders of thyroid. Monoclonal antibodies to serum thyroglobulin were developed.

The radioimmunoassay developed for detection of TB antigen has proved to be very useful in the diagnosis of non-pulmonary tuberculosis and also in studying the response to treatment. Radioimmunoassay for some of the common brain antigens like Myelin basic protein and cilial fibrillary acidic protein are being standardised to study the effect of brain involvement due to infections, tumours and toxins resulting in brain damage. Methods are being developed to study diseases such as leprosy and malaria.

Publications

V. Abraham, "Inheritance of ten induced mutants in okra (*Abelmoschus esculentus* (LINN) MOENCH", *Curr.Sc.* **54** (*18*) (1985) 931-935.

C.R. Bhatia, G.S.S. Murthy and V.H. Mathews, "Regeneration of plants from De-embryonated peanut cotyledons cultured without nutrients and agar", *Z.Pflanzenzuchtung* **94** (1985) 149-155

V. Helena Mathews, C.R. Bhatia, R. Mitra, T.G. Krishna and P.S. Rao, "Regeneration of plants from *Brassica juncea* (Linn.) Czearn and Coss cells transformed by *Agrobacterium tumefaciens* and expression of nopaline dehydrogenase genes", *Plant Science* **39** (1985) 49-54

T.G. Krishna and C.R. Bhatia, "Vicilin from Cajanus cajan seeds," *Phytochemistry* **24** (1985) 2201-2203

N.K. Notani and C.R. Bhatia, "Transposable elements of maize and other vectors for plant DNA transfer", *Reviews in Biotechnology Series* **1**, 1-36, NBTB DST, 1985

C.R. Bhatia, D.C. Joshua and Helena Mathews, "Somaclonal variation: A genetic interpretation based on rates of spontaneous chromosomal aberrations and mutations", *In. Trend. Plant Research* (1985) 317 - 326

C.R. Bhatia, R. Mitra and Helena Mathews, "Vectors for plant genetic engineering", in *Genetic Manipulation for Crop Improvement* (Ed. V.L. Chopra), New-Delhi, 1985, 261-289

V. Abraham, "The flora of Trombay", *B.A.R.C.–1279* (1985).

V. Abraham and C.R. Bhatia, "Utilization of yellow seeded Trombay mustard mutants in cross breeding", *Mut. Breeding News Letter* **25** (*3-4*), (1985).

C.R. Bhatia, "Irradiation to improve crom plants", Hindu, December 16, 1985.

S.G. Bhagwat, K.N. Suseelan, M.V.P. Rao and C.R. Bhatia, "Selection of flag leaf blade area and stomatal frequency in bread wheat", Proc. 3rd Nat. Seminar on Genetics and Wheat Improvement, Shimla, May 8-10, 1985

C.R. Bhatia, Helena Mathews and R. Mitra, "Vectors for genetic transformation of plant cells", Proc. Symposium on Newer Approaches to Biological Application, DAE, Bombay, 1985; 159-165

C.R. Bhatia, Helena Mathews and R. Mitra, "Plant gene manipulation: Vectors for DNA transfer", Workshop on Plant Molecular Biology, DAE Bombay, 1985; 181-194

C.R. Bhatia, G.S.S. Murthy, Chandra Mouli and D.M. Kale, "Regeneration of M1 plants from de-embryonated cotyledons to modify diplontic selection", FAO-IAEA Int. Symp. on Nuclear Techniques and In-vitro Culture for Plant Improvement, Vienna, Aug. 19-23, 1985.

M.V. Prabhakar Rao, "Incorporation of the alien gene Sr26 and Sr27 for stem rust resistance in Indian wheats", Proc. 3rd Nat. Seminar on Genetics and Wheat Improvement, Shimla, May 8-10, 1985.

R. Mitra, "Stress induced and heat shock proteins in plants", Workshop on Plant Molecular Biology, DAE, Bombay, 1985; 89-111

T.G. Krishna, "Seed storage protein genes", *ibid.*,113-129

B.N. Vyas and K.B. Mistry, "Hydrolysis of prilled urea, sulphur-coated urea and urea sulphur granules in an oxisol, vertisol and inceptisol", *Ind. J. Agric. Sci* **55** (1985) 35-39.

V.B. Yadav and K.B. Mistry, "Evalution of ammonium ortho and polyphosphates as carriers of zinc for maize-bean sequence", *J. Nucl. Agric. Biol.* **14** (1985) 102-104

V.V. Athalye and K.B. Mistry, "Studies on the mobility of selenium in three Indian soils", Nat. Seminar on Recent Advances in Soil Research, Ind. Soc. Soil Sci., Anand, Nov. 4-7, 1985.

S. Ramani and S. Kannan, "Studies on translocation of zinc in bean plants: Evidence for retransformation during new growth", *J. Plant Physiol.* **121** (1985) 313-318

S. Ramani and S. Kannan, "Study of heterosis in relation to nutrient uptake in some sorghum cultivars of sorghum and maize: Differences amongst hybrids and their parents", *J. Plant Nutr* **8** (1985) 1199-1210

S. Ramani and S. Kannan, "Studies on Zn uptake and influence of Zn and Fe on chlorophyll development in young maize cultivars", *ibid.*, 1183- 1189.

S. Kannan, "Fe-deficiency tolerence in papaya (*Carcia papaya* L) :pH reduction and chlorosis recovery in response to stress", *ibid.*,(1985) 1191-1197

A.S. Nirale and S. Kannan, "Study of heterosis in relation to nutrient uptake in some sorghum cultivars", Nat. Seminar on Plant Physiology, Ind. Soc. Plant Physiology, Imphal, Dec. 15-17, 1985; Session V, P.3

A.S. Nirale, I.C. Dave and S. Kannan, "N-benzyladenine induced changes in 86 Rb uptake in sunflower cotyledons and embryoaxis", *ibid.*,p.5, Abst. 10

S. Kannan, "Iron nutrition of crop plants: Its regulation through chemicals excreted by the roots under iron stress", *ibid* p.4. Abst.7

S. Ramani and S. Kannan, "Differential uptake of sodium by salt-tolerant and salt susceptible rice cultivars", *ibid.*, p.3, Abst.5

P. Narahari and N.P. Sarma, "Role of induced mutations in rice improvement", 1st Nat. Symp on Rice Genetics, Directorate of Rice Research, Hyderabad, April 16-17, 1985

P. Narahari, "TR-5 Dwarfing gene in rice", Int. Rice Genetics Syposium, IRRI Manila, Philippines, May 27-31, 1985.

P. Narahari, "Agronomic and genetic evaluation of induced mutants of Luchai-112", FAO/IAEA Co-ordinated research programme on evaluation of semi-dwarf cereal mutants for cross breeding, ENEA/FARE Research Centre, Rome, Italy, Dec. 16-20, 1985.

K. Raghu, J. Drego and J. Mitra, "Biodegradation as a means of decontamination of pesticide-polluted soils", 10th Ann. Conf. Environmental Mutagen Society of India, B.A.R.C., Bombay 1985; 148.

K. Raghu and J. Drego, "Bound residues of lindane: magnitude microbial release plant uptake and effect on microbial activities", 3rd Co-ord. Meeting on Isotopic Tracer-Aided Studies of Bound Residues in Soils, Plants and Food, Gainesville, U.S.A. 1985.

S.K. Apte, "Metal ions in biological nitrogen fixation", Proc. DAE Symp. Current Status of Biological Nitrogen Fixation Research, 1986; 97-99

S.K. Apte and J. Thomas, "Effect of sodium on membrane potential, uptake of phosphate, nucleoside phosphate pool and synthesis and expression of nitrogenase in *Anabaena torulosa*",*Indian J. Exp. Biol.* **23** (1985) 518-522.

S.K. Apte and J. Thomas, "Membrane electrogenesis and sodium transport in filamentous nitrogen-fixing cyanobacteria", *Eur. J. Biochem.* **154** (1986) 395-401.

A.A. Bhagwat, "Early interactions in legume-*Rhizobium* symbiosis", Proc. DAE Symp. Current Status of Biological Nitrogen Fixation Reseach, 1985; 39-40.

M. D'Souza and N.K. Notani, "Isolation of plasmids from *Rhizobium meliloti* and their potential as plant vectors", Proc. DAE Symp. Newer Approaches to

Biological Applications, 1986; 178-182.

T.S. Desai and R.T. Ross, "Characteristics of the relative maximum in the decay of delayed light emission from *Pothos* leaf following far-red excitation", *Photosynthesis Research* (1985)

B.K. Gaur, "Physiological Responses of plants to ionizing radiation", *Ind. J. Plant Physiol.***28**(*1*) (1985) 1-13.

B.K. Gaur, "Hormonal control of plant behaviour: A futuristic outlook", Prof. Joshi Memorial Lecture (First), Shivaji Univ., Kolhapur, 1986.

K.C. George and B.B. Singh, "Hyperthermic response of a mouse Fibrosarcoma as modified by Phenothiazine drugs", *Brit. J. Cancer* **51** (1985) 737-738.

L. George, D.R. Suryavanshi, A.T. Sipahimalani and V.T. Srinivasan, "Oil content and fatty acid composition of mustard seeds obtained through tissue culture", Proc. Ind. Nat. Sci. Acad. **(B)**,**51** (1985) 1-4.

R.P. Kanade and N.K. Notani, "Partial suppression of UV-sensivity by plasmids in *Haemophilus", Ind. J. Exptil. Biol.* **24** (1986) 108-111

R.P. Kanade and N.K. Notani, "Self-cloning in *Haemophilus influenzae* of *uvr 1* gene", Proc. DAE Symp. Newer Approaches to Biological Applications, 1985;141-143.

S.D. Mishra and B.K. Caur, "Modification of flag leaf senescence and yield characters in barley (*Hordeum vulgare*)by gibberellic acid and kinetin", **J.** *Plant Growth Regulation* **4** (1985) 63-70

G.B. Maralihalli and A.S. Bhagwat, "Interaction of pyridoxal phosphate with the amino groups at the active site of maize δ-amino levulinic acid dehydratase", *J. Biosciences* **7** (1985) 359-364.

G.B. Maralihalli, S.R. Rao and A.S. Bhagwat, "Histidine residues at the active site of maize δ-amino levulinic acid dehydratase", *Phytochemistry* **24** (1985) 2533-2536.

H.S. Maniar and B.B. Singh, "Radiosensitising and radioprotective effects of phenothiazines", *Ind. J. Exptl. Biol.* **23** (1985) 100-102.

K.P. Mishra, M.C. Patel, R.D. Ganatra and B.B. Singh, "Encapsulation and targetting of drugs in electrically hemolysed red cells", *Biblthca Haemat.* **51** (1985) 115-126.

N.K. Notani, "Organization of plant genomes", in *Genetic manipulation for crop improvement*,1985; 251-259

N.K. Notani and R.P. Kanade, "DNA Repair and Mutagenesis", (Invited article) *Current Science* **54** (1985) 832-839.

N.K. Notani and M. D'Souza, "Genetic transformation in bacteria and in plants for productivity", Proc. Int. Workshop on Molecular Biosciences and Biotechnology, Madras, 1986.

N.K. Notani, R.P. Kanade and N.V. Khalap, "Genetic and Molecular Biology of *Streptomyces*", Indian National Science Academy Golden Jublee Publication, 1986; 24

N.K. Notani and C.R. Bhatia, "Transposable elements of maiza and other vectors for plant DNA transfer", (*NBTB*) *Reviews in Biotechnology* (Series *1*) (1985) 1-35.

S.R. Rao, G.B. Maralihalli and A.S. Bhagwat, "Inhibition of -aminolevulinic acid dehydratase by 2,4,6 trihydroxybenzoic acid", *Ind. J. Expt. Biol.* **23** (1985) 715-718.

S.S. Rane and P.V. Sane, "Characterization of glow peaks of chloroplast membranes: Part IV: Identification of different components of delayed light with the glow peaks of chloroplasts", *ibid.*, 370-374.

V.T. Srinivasan, B.B. Singh, P.K. Chidambareswaran and V. Sundaram, "Estimation of cotton seed oil by pulsed NMR technique", *J. Amer. Oil. Chem. Soc.* **62** (1985) 1021-1025.

M.A. Shenoy and B.B. Singh, "Temperature-dependent modification of radiosensitivity following hypoxic cytocidal action of chlorpromazine", *Radiat. Environ. Biophysics* **24** (1985) 113-117.

M.A. Shenoy and B.B. Singh, "Non-nitro radiation sensitisers: A Review", *Int. J. Radiat. Biol.* **48** (1985) 315-326.

B.B. Singh, "Radiation treatment of malignancies in combination with drugs: a new strategy", *Artificial Radioactivity* (Eds. K.N. Rao and H.J. Arnikar), Tata McGraw-Hill Publishing Co., 1985; 454.

V.T. Srinivasan, B.B. Singh, P.K. Chidambareswaran and V. Sundaram, "Effect of hydrogen content on estimation of seed oil by pulsed NMR", **J.** *Amer. Oil. Chem. Soc.* (1986)

B.B.Singh, "New Chemo- and radiosensitising drugs - a book review (by invitation)", *Int. J. Radiat. Biol.* (1986).

J. Thomas and A.A. Bhagwat, "Initial interactions in the nitrogen-fixing legume-*Rhizobium* symbiosis", Proc. Int. Workshop on Molecular Biosciences and Biotechnology, Madras, 1986.

J. Thomas, S.K. Apte, A.A. Bhagwat, A. Vachhani, T. Fernandes and R. Tuli, "Aspects of cyanobacterial nitrogen fixation, early interactions in legume-*Rhizobium* symbiosis and prospects for genetic manipulation", Proc. Int. Workshop on Biotechnology in Agriculture: Evolving a Research Agenda for ICGEB: UNIDO, Vienna and Dept. of Science & Technology, New Delhi, 1986.

N.C. Verma and A.S. Bhagwat, "Energy transfer from tryptophan residues to pyridoxal phosphate at the active site of Ribulose 1,5-hisphosphate carboxylase", *Biochem. Biophys. Res. Commus.* **129** (1985) 256-261

N.C. Verma, "Fluorescence from L-tyrosine and its quenching by phosphate ions and DNA", *Ind. J. Biochem. Biophys.* **22**(1985) 218-222.

O.P.D. Noronha, H.H. Shimpi and N. Aravind, "Product development of ^{99m}Tc-iodotrimethida", XVII Annual Conf. of Soc. Nucl. Med., India, Bangalore, Jan.1-5, 1986.

O.P.D. Naronha, "Pharmacokinetics of ^{99m}Tc-MDP in rats with altered thyroid status", *ibid*.

G.D. Nadkarni, H.H. Shimpi and O.P.D Noronha, "Disposition of ^{99m}Tc.labelled R.E. and hepatobiliary radio-pharmaceuticals in an animal model of liver cirrhosis", *ibid*.

D.N. Pahuja and O.P.D. Noronha, "Effect of altered thyroid status an the transport of hepatobiliary radiopharmaceuticals", *J. Nucl. Med.* **16** (1985) 1168-1171

O.P.D. Noronha, "Solvent extraction technology of ^{99}Mo-^{99m}Tc generator system performance characteristics", in *Radiopharmaceuticals and Labeled Compunds,* IAEA Proc. Conf., Tokyo, Oct. 1984; 223-232.

O.P.D. Noronha, "Solvent extraction technology of ^{99}Mo-^{99m}Tc generator system, Practical aspects of radiation protection in the hospital radiopharmacy during the work up of the radiopharmaceutical sodium pertechnetate (99m.Tc)", AMPI *Medical Physics Bulletin* **10** (1985) 78-86

O.P.D. Noronha, "Radiobiologic (tissue) profiles of ^{99m}Tc-diagnostics behaviour of Tc-99m N-p (butylphenylcarbamoylmethyl) iminodiacetic acid, (99mTc-p-butyl HIDA), in normal rats", *J. Radioanalytical and Nuclear Chemistry* (Letters) **94**, (1985) 139-148.

O.P.D. Noronha and A.B. Sewatkar, "A reassessment of the hepatobiliary profensities of 1-131-Rose Bengal in the rat", *Isotopenpraxis* 21 (1985)

92-96

O.P.D. Noronha, "A simple remote-controlled shielded assembly for membrane filtration of radioactive solutions", *Bulletin of Radiation Protection* **7** (4) (1984) 83-85

Ajaykumar, M.N. Devdhar, D.H. Shah and R.D. Ganatra, "Use of double antibody and staphylococcus aureus as a separating agent in RIA of thyroglobulin", *Ind. J. Med. Research* **82** (1985) 248.

D.H. Shah, M.N. Devdhar, R.D. Ganatra, R.N. Kale, S.S. Virdi and M.D. Deshmukh, "Modified rapid radiometry method for detection of Mycobacterium tuberculosis from sputum samples", *Int. J. Nucl. Med. Biol.* **12** (1985) 333.

D.H. Shah, M.N. Devdhar, R.D. Ganatra, R.N. Kale, S.S. Virdi and M.D. Deshmukh, "A combined detection and drug susceptibility testing of Mycobacterium tuberculosis in smear positive sputum samples using biphasic vial radiometric method", *Ind. J. Med. Res.* **83** (1986) 123.

D.H. Shah, Ajaykumar, S.R. Dandekar, U. Vijayan, B.A. Krishna and S.M. Sharma, "Serum thyrogloblulin in management of thyroid cancer", Proc. of International Symp. on nuclear medicine and related medical applications of nuclear techniques in developing countries, Vienna, Austria, 1985; 26-30.

R.K. Jeevanram, D.H. Shah, S.M. Sharma and R.D. Ganatra, "Influence of initial large dose on subsequent uptake of therapeutic radioiodine in thyroid cancer patients", *Int. J. Nucl. Med and Biol.* (in print).

G.D. Nadkarni and K.N. Pestonjamasp, "Effect of ethanol on turpentine-indiced acute response in rats", *Biochem. Pharmacol* **34** (1985) 525-528

N.B. D'Souza, A.B. Kulkarni, A.J. Baxi and G.D. Nadkarni, "Enzymetic defence against oxygen toxicity in D- galastosamine-induced hepatitis in rats", *Ind. J. Gastroenterol* **4** (1985) 87-88.

G.D. Nadkarni and K.N. Pestonjamasp, "Effect of long-term feeding of eggs on liver and plasma proteins", *Ind. J. Clin-Biochem.* **1** (1986) 8-12.

A.M. Samuel, "Circulating Immune Complexes in Pulmonary Tuberculosis". *J. of Clin. & Lab. Immunology* (October 1985).

A.M. Samuel, "Myelin Basic Protein determination in CSF of Children with Tubercular Meningitis", Proc. IAEA Symp. of Nuclear Techniques in Developing Countries, Aug. 1985.

A.M. Samuel, "Radionucleide scintigraphy of brain and ultrasound studies in Tubercular Meningitis", *Clinical Radiology* (in press).

L.S. Mani, K.B. Desai, L.J. Joseph and R.D. Ganatra, "Intestinal Absorption of Labelled Triodothyronine in Man", *Ind. J. Gastroenteral* **4** (1985) 239-241.

V.A. Bapat, R. Gill and P.S. Rao, "Regeneration of somatic embryos and plantlets from stem callus protoplasts of sandalwood tree (*Santalum album L.*", *Curr. Sci.* **54** (1985) 978-982.

C.R. Bhatia, G.S.S. Murthy and V.H. Mathews, "Regeneration of plants from de-embryonated peanut cotyladons cultured without nutrients and agar", *Z. pflanzenzuchtung* **94** (1985) 149-155.

C.R. Bhatia, R. Mitra and V.H. Mathews, "Vectors for plant genetic engineering". in *Genetic manipulation for crop improvement*, M.S. Swaminathan's Commemoration Volume (ed. V.L. Chopra) (1985) 261-291.

C.R. Bhatia, D.C. Joshua, V.H. Mathews, "Somaclonal variation a genetic interpretation based on spontaneous mutation rates and chromosomal aberrations", *In Trends Pl. Res.* (eds. C.M. Govil and V. Kumar) (1985) 317-326.

C.R. Bhatia, V.H. Mathews and R. Mitra, "Plant gene manipulation : Vectors for DNA transfer", Workshop on Plant Molecular Biology, National Chemical Laboratory, Pune, India, 1985; 181-185.

S. Eapen and P.S. Rao, "Plant regeneration from immature inflorescence callus cultures of wheat, rye and triticale", *Euphytica* **34** (1985) 153-159.

S. Eapen and P.S. Rao, "Factors controlling callus initiation growth and plant regeneration in Breadwheat (*Tricticum aestivum* L)", *Proc. Indian Acad. Sci.* **94** (1985) 33-40.

S. Eapen and P.S. Rao, "Regeneration of plants from callus cultures of *Anthurium Patulum*", *Curr. Sci.* **54** (1985) 641-642.

S. Eapen and P.S. Rao, "Factors controlling pollen embryogenesis in *Tricticale* and wheat", *Proc. Indian Natn. Sci. Acad.* **B51**(1985) 353-359.

L. George, "Anther culture of *Catharanthus roseus* L. development of pollen embryoids", *Curr. Sci.* **54** (1985) 641-642.

L. George, D.R. Suryavanshi, A.T. Sipahimalani and V.T. Srinivasan, "Oil content and fatty acid composition of mustard seed *(Brassica juncea* L) obtained through tissue culture", *Proc. Indian Natn. Sci. Acad.* **B51** (1985) 1-4.

R. Gill and S. Eapen, "Plant regeneration from hypocotyl protoplasts of mothbean (*Vigna aconitifolia*)", *Curr. Sci.* **55**(*2*) (1985) 100-102.

M.R. Heble, "Multiple shoot cultures: Available alternative in vitro system for the production of known and new biologically active plant constituents", *in Primary and Secondary Metabolism of Plant Cell Cultures* (eds. K.H. Neumann, W. Barz, E. Reinhard), Springer-Verlag, Berlin, 1985, 281-289.

V.H. Mathews, C.R. Bhatia, R. Mitra, T.G. Krishna and P.S. Rao, "Regeneration of shoots from *Brassica juncea* (Linn.). Czern and coss cells transformed by *Agrobacterium tumefaciens* and expression of nopaline dehydrogenase genes", *Plant Sci. Lett.* **39** (1985) 49-54.

V.H. Mathews and P.S. Rao, "In vitro culture of *Vanda* hybrid (*Vanda* TMA X *Vanda* Miss. Joaquim) I. studies on protocorm explants", *Proc. Indian Natn. Sci. Acad.* **B51** (1985) 96-103.

V.H. Mathews and P.S. Rao, "In vitro culture of *Vanda* hybrid (Vanda TMA X Vanda Miss. Joaquim) II studies on seedling explants", *Proc. Indian Natn. Sci. Acad.* **B51** (1985) 496-504.

V.H. Mathews and P.S. Rao, "Propagation of **Vanda** hybrids using tissue culture", in *Progress in Orchid Research* (eds. K.L. Chadha and Foja Singh), Indian Institute of Hort. Res., Bangalore, India, 1985; 105-109.

M. Mhatre, V.A. Bapat and P.S. Rao, "Regeneration of plants from the culture of leaves and axillary buds in mulberry (*Morus indica* L)", *Plant Cell Reports* **4** (1985) 78-80.

M. Mhatre, V.A. Bapat and P.S. Rao, "Micropropagation and protoplast culture of peanut (*Arachis hypogaea*)", *Curr. Sci.* **54** (1985) 1052-1056.

P.S. Rao and P. Ozias-Akins, "Plant regeneration through somatic embryogenesis in protoplast cultures of sandalwood (*Santalum album* L.)", *Protoplasma* **124** (1985) 80-86.

P.C. Roja, B.D. Benjamin, M.R. Heble and M.S. Chadha, "Indole alkaloids from multiple shoot cultures of Rauwolfia serpentina", *Planta Medica* **1** (1985) 73-74.

V. Thomas and P.S. Rao, "In vitro propagation of oil palm (*Elaeis quinensis* Jacq. var tenera) through somatic embryogenesis in leaf derived callus", *Curr. Sci.* **54** (1985) 184-185.

G.S. Verma, V. Ramakrishnan, N.B. Mulchandani and M.S. Chadha, "Antifeedant compounds from *Tylophora asthmatica*" National symposium on insect physiology, ecology and behaviour, University of Kerala, Trivandrum, Feb. 18-20, 1986.

G.S. Verma, V. Ramakrishnan, N.B. Mulchandani and M.S. Chadha, "Insect antifeedant from *Tylophora asthmatica* (Asclepiadaceae)", *Entomologia experimentalis at applicata* (1985, in press)

K.G. Raghavan and V. Ramakrishnan, "Fabrication of reusable enzyme brushes for clinical analysis: Determination of lactate dehydrogenase", *Biotech. Bioeng.* (in press)

K.G. Raghavan, T.P.A. Devasagayam and V. Ramakrishnan, "Immobilized enzyme brushes for clinical analysis: Urea determination", *Anal. Lett.* (*B*) (in press)

K.M. Lathika, "Biological effects of plumbagin on development of red cotton bug *Dysdercus koenigii*", National symposium on insect physiology, ecology and behaviour, University of Kerala, Trivandrum, Feb. 18-20, 1986.

A. Banerji and N.C. Goomer, "Synthesis of cycloartocarpesin trimethyl ether", *Synthetic Communications* (in press).

A. Banerji and N.C. Goomer, "Synthesis of Ruberaflavone-A Trimethyl Ether", *Indian Journal of Chemistry* (in press)

A. Banerji and G.J. Chintalwar, "Role of Amino Acids in Terpenoid Biosynthesis", Plenary Lecture at the Third International Conference on Chemistry and Biotechnology of Biologically Active Natural Products, Sofia, Bulgarian Acadamy of Sciences, III, (1985), 285.

A. Banerji and N.C. Goomer "Structure Elucidation of Dimer of 6-Hydroxy-2, 2-dimethyl chromene by mass spectrometry", Third National Symposium on Mass Spectrometry - Research, Application and Instrumentation, RRL, Hyderbad, Sept. 1985; C-23

A. Banerji, G.J. Chintalwar and N.K. Joshi, "Phytochemicals-Unique Source of Bio-Active Compounds", Fifth ISHS International Symposium on Medicinal Aromatic and Spice Plants, Mongpoo, Feb. 1985; (C-9)

A. Banerji, "Minor Pathways to Isoprenoid Biosynthesis", Plenary Lecture at the Second National Symposium on Recent Advances in Organic Chemistry, University of Kalyani, Kalyani, March 1986; (PL-6).

Bharathi Prabhu and N.B. Mulchandani, "Lignans from Piper cubeba", *Photochemistry* **24** (*2*) (1985) 329

Bharathi Prabhu and N.B. Mulchandani, "Biosynthesis of piperlongumine", **ibid. 24** (11) (1985) 2589

Ashok V. Vyas and N.B. Mulchandani, "Benzene-induced ^{1}H NMR shifts of flavone protons. Detection of H-3", *Magnetic Resonance in Chemistry* (1986, in press).

Ashok V. Vyas and N.B. Mulchandani, "Polyoxygenated flavones from Ageratum Conyzoids," *Phytochemistry* (in press)

Beena Bakshi, N.B. Mulchandani and J. Shankar, "A novel phenalenone from Salvia moorcraftiana", *Planta Medica* (in press).

L.P. Badheka, Bharathi Prabhu and N.B. Mulchandani, "Dibenzylbutyrolactone lignans from Piper cubeba", *Phytochemistry* **24** (*2*) (1986) 489.

G.S. Verma, V. Ramakrishnan, N.B. Mulchandani and M.S. Chadha, "Insect feeding deterants from Tylophora asthmatica", *Ent. Exp. Appl.* 1985, (in press).

L.P. Badheka and N.B. Mulchandani, "Chemical constituents of Piper cubeba", *Photochemistry* (1986 in press).

Ashok V. Vyas and N.B. Mulchandani, "Synthesis and structures of dimeric and trimeric precocene-I analogs", *J. Chem. Res.*, (1986, in press).

Beena Bakshi, N.B. Mulchandani and J. Shankar, "Abietane diterpene quinones and a new diterpene expoxide from *Salvia moorcraftiana*", *Proc. Ind. Acad. Sci.* (1986, in press).

L.P. Badheka, B.R. Prabhu and N.B. Mulchandani, "Lignans from Piper cubeba", 22nd Annual convention of Chemists, Ravishankar University, Raipur (MP), Nov. 4-8, 1985.

S.V. Trivedi and V.R. Mamdapur, "Synthesis of 14-Methylpentadecan-3-one", *Indian J. Chem* (in press)

R.R. Iyer, V.R. Mamdapur and M.S. Chadha, "Convenient Synthesis of 4-Acetyl-2-methoxy-5-methyltriacontane and 23-Hydroxytriacontane-2-one", *J. Indian Chem. Soc.* (in press)

R.R. Iyer and V.R. Mamdapur, "Plant Growth Regulators: Synthesis of n-Triacontynols, n-Triacontenols and n-Triacontanols", *Indian J. Chem.* (in press).

A.R. Amin, T. Shah, V.V. Modi, S.R. Udupa and M.S. Chadha, "Microbial transformation of phytosterols from plant latices", *J. Ferment. Technol.* **63** (1985) 279-281.

S.R. Udupa and M.S. Chadha, "Biodegradation of Environmental Aromatic Pollutants", Seventy-Third National Symposium of Indian Science Congress, Delhi, Jan. 3-8, 1986 (Abstr.8, p.17-18).

S.R. Udupa and M.S. Chadha, "Liquid chromatographic separation of biotransformation products of (±) flavanone", National Symposium on Recent Trends in Analysis of Food, Drugs and Pharmaceuticals, Bhabha Atomic Research Centre, Bombay, June 22-29, 1985 (Abstr. B19, p. 14-15).

S.R. Udupa, "Biotransformation of progesterone by *Rhizopus arhizus*", Workshop in Industrial Microbiology, Dept. of Microbiology, Sophia College, Bombay, April 27-May 5, 1985, 25-27.

G.W. Rahalkar, A.J. Tamhankar and K.K. Gothi, "Selective breeding for reduced male response to female sex pheromone in Trogoderma Granarium Everts (Coleoptera: Dermestidae).

G.B. Nadkarni, "Isotope applications in radiation preservation of foods", Golden Jubilee Seminar of Department of Chemical Technology, University of Bombay, Jan. 4, 1985

C. Bandyopadhyay, "Separation techniques for lipids", *ibid.*, Feb. 22, 1985

S.R. Padwal-Desai, "Constituents of natural lipids", *ibid.*, Feb. 22, 1985.

S.R. Gandhi, M.D. Pednekar and M.S. Netrawali, "Effects of synthetic pesticides - endosulfan, malathion and permethrin on sexual cell cycle of *Chlamydomonas reinhardtii*", Tenth Annual Conf. of Environmental Mutagen Society of India, Bombay, Feb. 18-21, 1985.

A.K. Sharma and S.R. Padwal-Desai, "Regulation of mycotoxin production by ethylene", *ibid.*

S.R. Padwal-Desai and A.K. Sharma, "Factors influencing aflatoxin production in foods", *ibid.*

R.C. Chaubey, P.S. Chauhan and K. Sundaram, "Radiation induced micronuclei in mouse peripheral erythrocytes", *ibid.*

B. Sonalkar, R.C. Chaubey, P.S. Chauhan and K. Sundaram, "Peripheral micronucleated erythrocyte - a simple measure of chromosomal damage during chronic exposure", *ibid.*

M. Aravindakshan, P.S. Chauhan and K. Sundaram, "Low dose effects of

ionizing radiations and chemical mutagens: Nature of dose response curves", *ibid.*

K. Krishnamurthy and D.R. Bongirwar, "Design considerations for food irradiators in developing countries", IAEA Symposium on Food Irradiation Processing, Washington D.C., March 4-8, 1985.

S.R. Padwal-Desai, M.A. Munasiri, A.S. Ghanekar, Arun Sharma and G.B. Nadkarni, "Improvement of quality of spices by gamma irradiation", *ibid.*

Dr. G.B. Nadkarni, "Isotope applications in radiation preservation of foods", National Symposium on Use of radiations and isotopes in agriculture, University of Kashmir, Srinagar, May 22-25, 1985.

Arun Sharma and S.R. Padwal-Desai, "Modified analytical techniques for detection and estimation of aflatoxin", Symposium on Recent Trends in the Analysis of foods, Drugs and Pharmaceuticals, Bombay, 27-29 June 1985.

A.S. Gholap and C. Bandyopadhyay, "The utility of gas-liquid chromatography in the quantitation of mango flavour", *ibid.*

V. Ninjoor, S.N. Doke and M.S. Gore, "Enzymatic analysis for the detection of spoilage in meat foods", *ibid.*

P.S. Chauhan, M. Aravindakshan and K. Sundaram, "Dominant lethal studies on Swiss male mice", IPCS Investigators' Meeting, France, May 15-21, 1985.

P.S. Chauhan, R.C. Chaubey and K. Sundaram "Micronucleus study in swiss male mice", *ibid.*

M. Aravindakshan, R.C. Chaubey, P.S. Chauhan and K. Sundaram, "Whole animal mutagenicity studies on quercetin - a naturally occuring flavonoid", Symposium on Genetic Toxicology of the Diet, Copenhagen, Denmark, June 21-22, 1985.

M. Aravindakshan, P.S. Chauhan and K. Sundaram, "Genotypic dependence of dominant lethal mutations in inbred mice", 4th International Conference on Environmental Mutagens, Stockholm, June 23-28, 1985.

R.C. Chaubey, B. Sonalkar, P.S. Chauhan and K. Sundaram, "Persistance and dose-dependent accumulation of micronucleated erythrocytes in peripheral blood of radiation and benzo(a)pyrene exposed mice", *ibid.*

S.F.D'Souza, "Immobilised biocatalysts: techniques, applications and challenges", Work-shop on Industrial Microbiology, Bombay, April 27-May 4, 1985.

S.F. D'Souza, "Biospecific affinity chromatography", *ibid.*

S.F. D'Souza, "Methods for immobilization of biocatalysts", *ibid.*

P. Harikumar, Brij Bhushan and V. Ninjoor, "Occurrence of alkaline proteinase in kidney lysosomes", Ann. Gen. Body Meeting of Society of Biological Chemists, Pantnagar, Nov. 7-9, 1985.

G.B. Nadkarni and S.F. D'Souza, "Stable multienzyme complexes through immobilized microbial cells", International Workshop in Molecular Biosciences and Biotechnology, SPIC, Madras, Aug. 21-23, 1985 (Abstract pp. 57-58).

A. Deshpande, S.F. D'Souza and G.B. Nadkarni, "Differential responses of D-amino acid oxidase and catalase in yeast cells to immobilization in polyacrylamide", 26th Ann. Conference of Assoc. of Microbiol. India, Madras 10-12 Oct. 1985.

S.F. D'Souza, A. Deshpande, S.S. Godbole and G.B. Nadkarni, "Immobilized yeast system for chemical production", National Symp. on Yeast Biotechnology, Haryana Agric. Univ., Hissar, 12-14 Dec. 1985.

K. Sankaran, "Differential properties of the mitochondrial phosphodiesterases in Yoshida ascites tumour bearing rats", 54th Annual Meeting of Society of Biological Chemists (India), Pantnagar, Nov. 1985.

A.S. Kamat and D.P. Nerkar, "Nature of toxins formed by *B. Cereus* Bis-59", 26th Annual Conference of the Association of Microbiologists of India, Madras, Oct. 10-12, 1985.

P.S. Chauhan, "Monitoring for genetic diseases in the new born", *The Indian Practitioner* **37** (1984) 981-994.

Arun Sharma, S.R. Padwal-Desai and G.B. Nadkarni, "Possible implication of reciprocity between ethylene and aflatoxin biogenesis in *A. Havis / A. Parasticus", Appl. Environ. Microbiol.* **49** (1985) 79-82.

P. Thomas and M.T. Janave, "Isoelectric focusing evidence for banana isoenzymes with mono and diphenolase activity", *J. Food Science* (in press).

P. Thomas, S.R. Padwal-Desai, A.N. Srirangarajan, M.R. Joshi, M.T. Janave, S.R. Bhonde and S.M.H. Qadri, "Pilot scale storage tests on the efficancy of gamma irradiation for sprout inhibition of onions under commercial storage conditions", *J. Food Science & Technology* (in press).

P. Thomas, "Radiation preservation of foods of plant origin. III. Tropical fruits: Bananas, mangoes and papayas", C.R.C. Critical Review in *Food Science & Nutrition* (in press)

V. Ninjoor and P.N. Srivastava, "Partial purification and characterization of an alkaline proteinase from the rabbit testes", *Gamete Res.* **11** (1985) 69-82.

P. Harikumar and J.P. Reeves, "Lysosomal proton pump", in *Membrane transport processes*, Proc. Conference: Smith Kline and French, Philadelphia, March 1985.

P. Harikumar and V. Ninjoor, "Influence of starvation on the intralysosomal proteolysis in rat liver," *Biochem. Indternational* **11** (1985) 311.

S.B. Warrier, V. Ninjoor and G.B. Nadkarni, "Purification and properties of β-glucuronides from the muscle of Bombay duck (Harpodon neherus)", *J. Food Sci.* **50** (1985) 997.

Brij Bhushan, V. Ninjoor and G.B. Nadkarni, "Activity of radiation degradation products of vitamins A and E to haemolyse erythrocyte", *J. Bioscience* **7** (1985) 303.

S.V. Sherekar, S.N. Doke, M.S. Gore and V. Ninjoor, "Proteinases of tropical fish and their role in autolysis", *Agric. Biol. Chem.* (in press).

P. Harikumar and V. Ninjoor, "Influence of starvation, Triton WR-1339 and ^{131}I-human serum albumin on rat liver lysosomes", *J. Bioscience* (in press).

A.C. Pansare, V. Venugopal and N.F. Lewis, "A note on the nutritional influence of extracellular protease synthesis in *Aeromonas hydrophila*," *J. Appl. Bacteriol.* **58** (1985) 101-105.

V. Venugopal, A.C. Pansare and N.F. Lewis, "Inhibitory effect of food preservatives on protease secretion by *Aeromonas hydrophila*", *J. Food Sci.* **49** (1984) 1078-1081.

A.C. Pansare, V. Venugopal and N.F. Lewis, "Fe^{++} inhibition of extracellular protease synthesis in *Aeromonas hydrophila*", *Agricultural & Biological Chem.* **49** (1985) 2451-2453.

V. Sen, D.P. Nerkar, A.S. Kamat and N.F. Lewis, "In vivo effect of lipoteichoic acid on biochemical functions of peritoneal macrophages", *Ind. J. Exptl. Biol.* (1985, in press).

A.S. Kamat, N.F. Lewis and D.S. Pradhan, "Mechanism of Ca^{++} and

dipicolinic acid requirement for L-alanine induced germination of *Bacillus cereus* Bis 59 spores", *Microbios.* **44** (1985) 33-44.

A.C. Pansare, N.F. Lewis and V. Venugopal, "Characterisation of extracellular proteases of *Aeromonas hydrophla*", *Agric. Bio. Chem.* (in press).

D.P. Nerkar and J.R. Bandekar, "Stimulation of macrophages and antitumor activity of a radiodetoxified lipopolysaccharides", *J. National Cancer Institute* (in press).

A.S. Kamat, N.F. Lewis and D.S. Pradhan, "Incorporation of L-alanine during spore germination", *Indian J. Microbiology* (in press).

V.S. Rao and U.K. Vakil, "Effects of gamma-radiation on cooking quality and sensory attributes of four legumes", *J. Food Sci* **50** (1985) 372-375.

U.R. Iyengar and U.K. Vakil, "Enumeration and structural assessment of peritoneal macrophages during progressive protein deficiency in rat", *J. Biosci.* **7** (1985) 15-26.

U.R. Iyengar and U.K. Vakil, "Effect of protein deficiency on selective elicitation of lysosomal enzymes in rat peritoneal macrophages", *ibid.*, **9** (1985) 23-33.

S.F. D'Souza, R. Kaul and G.B. Nadkarni, "A method for the preparation of hen egg white beads containing immobilized biocatalysts", *Biotechnol. Letters* **7** (1985) 589.

R.Kaul, S.F. D'Souza and G.B. Nadkarni, "Co-immobilized glucose oxidase *E. coli* cell conjugate for the hydrolysis of lactose in milk and its preservation", *J. Microbial Biotechnol.* (in press).

G.B. Nadkarni and S.F. D'Souza, "Stable multienzyme complexes through immobilized microbial cells", Proc. of International Workshop on Molecular Biosciences and Biotechnology, SPIC, Madras, 1985 (in press).

B.S. Kubal, S.S. Godbole and S.F. D'Souza, "Preparation and characterization of magnetic hen egg white beads containing coimmobilized glucose oxidase, magnetite and MnO_2", *Ind. J. Biochem. Biophys.* (in press).

A. Deshpande, S.F. D'Souza and G.B. Nadkarni, "Coimmobilization of D-amino acid oxidase and catalase by entrapment of *Triqonopsis variabilis* cells in radiation polymerized polyacrylamide beads", *Biotechnol. Bioeng.* (in press).

A. Deshpande, S.F. D'Souza and G.B. Nadkarni, "Immobilization of microbial cells acrylamide by radiation polymerisation", Proc. DAE Symp. on Newer approach to biological application, Baroda, 1985; 62-67.

S.S. Godbole, R. Kaul, S.F. D'Souza and G.B. Nadkarni, "Denitrification of water by immobilized *Pseudomonas* denitrificans cells", *ibid.* 48-56.

P. Kaul, S.F. D'Souza and G.B. Nadkarni, "Activation of antibacterial lactoperoxidase system in milk with coimmobilized fructose oxidase-E coli conjugate", *ibid.*, 74-80.

K. Sankaran, "Endogenous protein inhibitor of mitochondrial c-AMP phosphodiesterase in tumour bearing rats", *Ind. J. Biochem. Biophys* (in press).

K. Sankaran, "Mitochondrial phosphodiesterases in the normal and Yoshida ascites tumour bearing rat liver", *Ind. J. Biochem. Biophys.* (in press).

C. Bandyopadhyay, A.S. Gholap and V.R. Mamdapur, "Characterization of alkenyl resorcinol in mango (*Magnifera indica L*) latex", *J. Agric. Food Chem.* **33** (1985) 377-379.

A.S. Gholap, C. Bandyopadhyay and G.B. Nadkarni, "Aroma development in mango fruit", *J. Food Biochem.* (1985, in press).

S.C. Tripathi, C. Bandyopadhyay, A. Ramanyam and M.N. Nadkarni, "Thin-layer chromatographic separation and quantification of dibutyl phosphoric acid in a mixture of monobutyl phosphoric acid and tributyl phosphate", *Analyst* (1985, in press).

S.C. Tripathi, K. Annaji Rao, C. Bandyopadhyay, A. Ramanyam and M.N. Nadkarni, "Chromatographic assay of degradation products of tributyl phosphate", *B.A.R.C. - 1272* (1985) 1-31.

C. Bandyopadhyay and B.Y.K. Rao, "Incidence of long chain n-alkanes in the volatiles of white pomfret caught off the west coast of India", *Ambio,* (1985, in press).

B.Y.K. Rao and C. Bandyopadhyay, "On the muscle lipid composition of white pomfret during ice temperature storage", *J. Food Sci. Tehcnol.*, (1985, in press).

T.P.A. Devasagayam and C.K. Pushpendran, "Kinetics of NADPH-induced lipid peroxidation in rat liver microsomal fractions as a function of age", *Biochem Int.* **11** (1985) 833-839.

Geeta Datta, S.S. Naik and Shantoo Gurnani, "Chemical characterization of the Dapsone binding site of lysozyme", *Int. J. Leprosy* **53** (1985) 428-432.

S.K. Jagtiani, L.M. Narurkar and M.V. Narurkar, "Transfer RNA methylases and carcinogenesis", *J. Biocsci.* **9** (1985) 13-22.

C.K.K. Nair, M.S. Priyolkar and D.S. Pradhan, "A simple procedure for the preparation of T_4DNA ligase", Proc. DAE Symp. on New Approaches to Biological Applications, Bombay, 1985; 128.

J.M. Naronha and S.V. Koppikar, "The fat receptors", *Science Today* **19** (*12*), (1985) 75.

V.N. Pande and D.S. Pradhan, "Production of radiolabelled nucleotides by microbial cells", Proc. DAE Symposium on New Approaches to Biological Applications, Bombay, 1985; 207.

M.S. Patil, S.E. Locher and P.V. Hariharan, "Radiation-induced thymine base damage and its excision repair in active and inactive chromatin of Hela Cells", *International J. of Radiation Biology* (1985) 691-700.

K.G. Raghavan and U. Tarachand, "Degradation of oxalate in rats implanted with immobilized oxalate", *FEBS Lett.* **195** (1986) 101-105.

K.G. Raghavan and T.P.A. Devasagayam, "Oxalate oxidase from banana peel for determination of urinary oxalate", *Clin. Chem.* **31** (1985) 649.

R. Rajagopalan and S. Gurnani, "Effect of Rifampicin on the biological activity of tubulin", *Biochem. Pharmacology* **34** (1985) 3415-3419.

R.R. Rajan and S.S. Katyare, "Cooperativity in inhibition of coupled and uncoupled respiration in rat liver and brain mitochondria by imipramine", *Ind. J. Biochem. Biophys.* **22** (1985) 71-77.

J.M. Shallon and S.S. Katyare, "Altered Synaptosomal ATPase activity in rat brain following prolonged in vivo treatment with nicotine", *Biochem. Phramacol.* **34** (1985) 3445-3449.

U. Tarachand, "Morphogenesis and postulated functions of decidual cells", *Bio. Res. Prog.* **6** (1985) 197.

U. Tarachand, "Metrial gland, structure origin, differentiation, and role in pregnancy", *Biol. Res. Prog.* **7** (1986) 34.

R.K. Bhattacharya, "Interaction of dietary factors with chemical carcinogens", *Proc. Nutr. Soc.* (in press).

R.K. Bhattacharya and R.S. Bagewadikar, "Functional modification of rat liver ribosome by the *in vitro* action of N-methyl N-nitro N-nitrosoguanidine", *Chem. Biol. Interact.* (in press).

T.P.A. Devasagayam, "Lipid peroxidation in rat uterus", *Biochem. Biophys.*

Acta (in press).

T.P.A. Devasagayam, "Low level of lipid peroxidation in newborn rats: Possible factors for resistance in hepatic microsome", *FEBS Lett.* (in press).

T.P.A. Devasagayam and C.K. Pushpendran, "Changes in ascorbate-induced lipid peroxidation of hepatic rough and smooth microsomes during postnatal development and ageing of rats", *Mech. Ageing Dev.* (in press).

P.F. Firozi, V.S. Aboobaker and R.K. Bhattacharya, "Modulation by certain factors of metabolic activation of aflatoxin B_1 as detected *in vitro* in a simple fluorimetric assay", *Chem. Biol. Interact.* (in press).

U.V. Gopalaswamy and A.S. Aiyar, "Biotransformation and toxicity of lindane and its metabolite hexachlorobenzene in mammals", Proc. International Symposium on Hexachlorobenzene, International Agency for Research on Cancer, W.H.O., Lyon, France, June 1985 (in press).

S.S. Katyare, "Effect of carbonyl cyanide m-chlorophenyl hydrozone on oxidative phosphorylation in rat liver mitochondria. Site specificity of its action", *Ind. J. Biochem. Biophys.* (in press).

S.S. Katyare, R.R. Rajan and U.V. Gopalaswamy, "Altered energy coupling in rat heart mitochondria following of *in vivo* treatment with propranolol", *Biochem. Pharmacol.* (in press).

S.M. Kelkar, "Rat liver UDPG dehydrogenase : Duel mechanism of regulation *in vivo", Arch. Biochem. Biophys.* (in press).

R. Mital, K. Son Ray, T.S. Srivastava and R.K. Bhattacharya, "Interaction of potential anticancer platinum complexes with DNA", *J. Inorg. Biochem.* (in press).

K.G. Raghavan and V. Ramakrishnan, "Fabrication of reusable enzyme brushes for clinical analysis lactate dehydrogenase enzyme brush", *Biotech. Bioeng.* (in press).

K.G. Raghavan, T.P.A. Devasagayam and V. Ramakrishnan, "Immobilized enzyme brushes for clinical analysis : urea determination", *Anal. Lett.* (in press).

R.R. Rajan and S.S. Katyare, "Effect of long term *in vivo* imipramine treatment of oxidative phosphorylation in rat brain mitochondria", *Neuropharmacology* (in press).

G.M. Shah and R.K. Bhattacharya, "Modulation by plant flavonoids and related phenolics of microsome catalyzed adduct formation between benzo(a) pyrene and DNA", *Chem. Biol. Interact.* (in press).

V.S. Aboobaker, P.F. Firozi and R.K. Bhattacharya, "Effect of retinol on DNA adduct formation by aflatoxin B_1 *in vitro*", Tenth Annual Conference of Environment Mutagen Society of India , Bombay, Feb. 18-21, 1985.

V.S. Aboobaker, P.F. Firozi and R.K. Bhattacharya, "Effect of natural factors on metabolic activation of aflatoxin B_1", 54th Annual Conference of Society of Biological Chemistry of India, Pantnagar, Nov. 7-9, 1985.

R.S. Bagewadikar and R.K. Bhattacharya, "Effect of the mutagen carcinogen N-methyl N'nitro N-nitrosoguanidine on mammalian ribosome function", Tenth Annual Conference of Environmental Mutagen Society of India, Bombay, Feb. 18-21, 1985.

D. Bhattacharjee, D.J. Charles and W. Pretsch, "Studies with ethylnitrosourea induced glucosephosphate isomerase deficient mutants of mice", Fourth International Conference on Environmental Mutagens, Stockholm, June 24- 28, 1985.

P.F. Firozi, V.S. Aboobaker and R.K. Bhattacharya, "A new fluorimetric assay for microsomal activation of aflatoxin B_1", Tenth Annual Conference of Environmental Mutagen Society of India, Bombay, Feb. 18-21, 1985.

P.F. Firozi, V.S. Aboobaker and R.K. Bhattacharya, "A simple fluorimetric procedure to assess microsomal activation of aflatoxin B_1", 54th Annual Conference of Society Biological Chemists of India, Pantnagar, Nov. 7-9, 1985.

Pasupathy Karpagam and D.S. Pradhan,"*De Novo* formation of mitochondrial DNA polymerase during transition in *Saccharomyces cerevisiae*",,13th International Congress of Biochemistry, Amsterdam, Aug. 25-30, 1985.

L.M. Narurkar, J.P. Kamat, N.A. Mhatre and M.V. Narurkar, "Status of hepatic glutathione in methionine-induced activity of the drug metabolising enzymes in rats", Tenth Annual Conference of Environmental Mutagen Society of India, Bombay, Feb. 18-21, 1985.

M.A. Nerurkar, J.G. Satav and S.S. Katyare, "Insulin-dependent changes in lysosomal cathepsin D activity in rat liver kidney, brain and heart", 54th Annual Meeting, Society of Biological Chemistry (India), Pant Nagar, Nov. 7-9, 1985.

A. Neuhauser-Klaus, D. Bhattacharjee and U.H. Ehling,"*In vivo* mutagenicity testing of diethylsulphate in mice", Fourth International Conference on Environmental Mutagens, Stockholm, June 24-28, 1985.

K. Pasupathy, K.G. Chetty, D.S. Pradhan, "An approach to study the distribution of chemical mutagens/carcinogens in mammals", Tenth Annual Conference of Environmental Mutagen Society of India, Bombay, Feb. 18-21, 1985.

D.S. Pradhan and K. Pasupathy, "Mitochondrial genome : Structure and distinctive participation in eukaryotic gene functions", Symposium on Genome in Flux, Annual Meeting of Indian Acadamy of Sciences, Madurai, Nov. 8, 1985.

J.G. Satav, F.R. Billimoria and S.S. Katyare, "Isolation of human thyroid mitochondria and characterisation of their respiratory attributes", Annual Conference of Association of Clinical Biochemists of India, Bangalore, February, 1985.

G.M. Shah and R.K. Bhattacharya, "Modulation of DNA-adduct formation by benzo (a) pyrene in vitro by plant flavonoids", Tenth Annual Conference of Environmental Mutagen Society of India, Bombay, Feb. 18-21, 1985.

J.M. Shallon and S.S. Katyare, "Altered Synaptosomal ATPase activity and cerebral protein tumour in rats following prolonged in vivo treatment with nicotine", International Symposium on Biomembranes Structure, Biogenesis and Transport, Madurai Kamaraj University, Madurai, Dec. 11-14, 1985.

Shyamla D. Desai, K.G. Chetty and D.S. Pradhan, "Effect of dimethyl sulfoxide on rat liver cytochrome oxidase", 54th Annual Meeting of Society of Biological Chemists (India), Pantnagar, November 7-9, 1985.

D. Bhattacharjee, W. Pretsch and U.H. Ehling, "Biochemical, genetical and haematological characterization of ethylnitrosourea-induced lactate dehydrogenase enzyme activity mutants", Eleventh Annual Conference of Environmental Mutagen Society of India, Madras, Feb. 20-22, 1986.

D. Bhattacharjee, "Biochemical approach to detect gene mutation", *ibid.*,

R.K. Bhattacharya, "Potential anticarcinogens : Nutrient and non-nutrient factors inhibiting carcinogen-DNA adduct formation", Second Biennial Conference, Indian Society of Oncology, Bombay, Feb. 9-14, 1986.

R.K. Bhattacharya, "Potential of vitamin A as a suppressor of carcinogenicity of aflatoxin B_1", Eleventh Annual Conference of Environmental Mutagen Society of India, Madras, Feb. 20-22, 1986.

F.R. Billimoria and S.S. Katyare, "Differential effects of triiodothyronine and thyroxine-inducted hyperthyroidism on energy metabolism in rat heart mitochondria", International Society of Heart Research, Satellite Meeting, Bombay, Feb. 5-6, 1986.

M.V. Nerurkar, J.P. Kamat, N.A. Mhatre and L.M. Nerurkar, "Induction of hepatic drug metabolising enzymes by normal metabolites in tumour bearing animals as an aid to cancer chemotherapy", Second Biennial Conference of Indian Society of Oncology, Bombay, Feb. 9-14, 1986.

T.K. Shetty, A.R. Rose and R.K. Bhattacharya, "Effect of certain dietary factors on the mutagenicity of aflatoxin B_1 in *S. Typhimurium* TA100", Eleventh Annual Conference of Environmental Mutagen Society of India, Madras, Feb. 20-22, 1986.

5. RADIOISOTOPES

5·1 Radioisotope Production

During the year, 1600 samples of various target materials were irradiated in the CIRUS and APSARA reactors. These included a set of 12 antimony pins irradiated in CIRUS for producing 150 curies of antimony-124 for use in start-up neutron sources for the FBTR reactor at Kalpakkam. Trial irradiation of molybdenum was carried out in the DHRUVA reactor for the production of molybdenum-99. A total of 50,000 consignments of radioisotopes and related equipment valued at Rs. 2·3 crores were supplied to the users in the country and abroad. Major supplies included 9 cobalt teletherapy sources supplied to various cancer hospitals, 4 gamma chamber units supplied for radiation research and 135 kilocuries of cobalt-60 sources installed at Isomed Plant at Trombay.

5·2 Radiochemicals

One hundred and seventytwo batches of various reactor produced radioisotopes totalling 950 curies of activity were processed during the year. About 1000 consignments of phosphorus-32 labelled super-phosphate were supplied for use in agricultural research. A total of 1000 tritium filled self-luminous sources were supplied to various defence establishments and 66 consignments of promethium-147 activated self-luminous compounds were supplied to various units of Indian Air Force.

5·3 Radiopharmaceuticals

During the period nearly 35,000 consignments of radiopharmaceuticals were supplied to over 100 user institutions in the country for use in nuclear medicine. It is estimated that about 500,000 patients would have benefited from the diagnostic and therapeutical applications of these products. Some of the more important applications have been in cardiology, early detection of endocrine disorders including hypothyroidism in new born babies and diagnosis of disorders of kidney, liver, lungs and brain. A new generator system for the production of technitium-99 m, from its parent molybdenum-99, at the hospital site, has been developed. Considerable progress was made in the development of new radiopharmaceutical products such as Technetium-99 m labelled DMSA, BCA-glucose, BCA-fatty acids for early detection of cancer, disorders of brain and heart function studies. Radioimmunoassay procedures have been developed for the mass screening of new born children for neonatal hypothyroidism. Development of RIA procedures for testesterone, aldosterons for use in early diagnosis of puberty disorders and hypertension has been undertaken. A hybridoma laboratory is being set up for large scale production of highly specific monoclonal antibodies required for improved RIA and immuno-scanning procedures. Extension services were provided to several hospitals and medical institutions from the regional centres for distribution of radiopharmaceuticals set up at Bangalore, Delhi and Dibrugarh.

5·4 Tritium, Carbon-14 and Phosphorus-32 Labelled Compounds

Labelled compounds of tritium, carbon-14 and phosphorus-32 were supplied to a large number of institutions in the country for use in research in bio-sciences, e.g. genetic engineering, biochemistry, drug research, enzyme biochemistry, etc. The R & D work for the indigenous production of P-32 labelled nucleotides required for use in biotechnology programme in the country was continued. The construction of the new C-14 and H-3 labelled compounds laboratory at Vashi, New Bombay is progressing as scheduled and is expected to be commissioned by mid 1987. The design of the laboratory for the production of P-32 labelled compounds has been completed and the construction work is expected to commence shortly.

5·5 Radiation Sources

A total of 2300 consignments of radiation sources of all types with an activity of approx 200,000 curies were supplied to various users. These include 11,600 curies of iridium-192 sources supplied for use in industrial radiography, 142,000 curies of cobalt-60 for use in industrial and research irradiators, 40,000 curies of cobalt-60 for

use in cancer therapy. Thirtysix numbers of tritium targets were supplied during the year.

5·6 Radioisotope Applications

Tracer Applications in Industry & Hydrology

Radiotracer investigations were carried out off the coast of Karwar to study the dispersal of effluents discharged by a caustic soda manufacturing unit into the sea. The dilution of the effluent in different directions at known distances from the discharge point was evaluated from the studies in order to confirm that the desired degree of dilution takes place in actual practice Radiotracer investigations carried out at an alumina plant confirmed that the mean residence time in different digestors of the alumina plant corresponded to the design value and that the residence time distribution corresponded to plug flow condition. A minute leak in the buried pipeline laid between the oil refineries at Trombay and Poona for the transport of petroleum, was detected using radiotracer technique. The leak was detected within a very short-time and at a low cost, thus enabling Hindustan Petroleum Corporation to rectify the pipeline in time for commissioning the same. Radioisotope studies were also carried out on this pipeline for locating blockages in the pipeline prior to its commissioning. A simple radioisotope based device has been developed for ONGC for providing an early warning of the arrival of a tool used in some of the production operations at the surface of oil well from inside the deep well. The early warning helps in preventing damage to the tool in the event it strikes against the derrick due to overshooting during the high speed retrieval operations.

Isotope studies carried out for the Irrigation Department of the Tamilnadu Government at the Minjur aquifer have shown that the salinity observed in the aquifer is largely due to the sea water intrusion to the ground-waters. The rate of inland movement of fresh water – salt water interface has been measured using the radiotracer method. The high salinity observed in certain pockets in the area is attributed to the leaching of salts in the nearby salt pans. Environmental stable isotope studies carried out in the Cauvery delta near Tanjavur in Tamilnadu showed that the shallow and deep ground waters in this area derive water from different sources. Radiotracer investigations carried out in the Hooghly estuary have provided useful information on the direction and rate of movement of silt on the river bed. These results will be helpful to the port authorities in assessing the suitability of the site currently being used for dumping the silt dredged from the Calcutta port.

Radiation Technology

The design and development of medium scale cobalt-60 gamma irradiation plant for research/commercial applications were continued. A large cobalt-60 irradiation facility is being installed at the Sri Ram Institute for Industrial Research, New Delhi, for work relating to radiation polymerization for research and pilot scale application. A project has been undertaken for setting up a medium sized (300 kilocuries cobalt-60) gamma irradiation plant for sterilization of medical products at the Kidwai Memorial Institue of Oncology, Bangalore, in co-operation with the Government of Karnataka. The civil works of the Sewage Hygeinisation Research Irradiator (SHRI) to be set up at Baroda for the treatment of domestic sewage is at an advanced stage of completion. The other works of the project are progressing satisfactorily and it is expected that the plant will be commissioned by early 1987.

Radiation Sterilization of Medical Products

The Isomed Plant at Trombay continued to offer gamma radiation services for sterilization of medical products to over 100 user industries. A total of 5,114 cu metres (180,646 cu ft) of medical products were sterilized at the plant thus registering an 18·6% increase over the volume of products sterilized in the plant during the previous year. Research and development work on the feasibility of radiation sterilization of pharmaceutical substances was continued. The physiochemical investigations carried out on gamma irradiated samples of nitrofurazon, sodium carboxymethyl cellulose and psyllium husk, showed the feasibility of sterilizing these products by radiation.

Industrial Radiography/Nucleonic Gauging

Twelve training courses in the field of industrial isotope radiography were conducted during the year which were attended by 475 industrial personnel, qualifying them to carry out either industrial radiographic inspection or to act as site-in-charge of industrial radiography installations. The scientists of Isotope Group actively participated in the activities of the UNDP (RCA) Project in Nondestructive Testing, for bringing about uniformity in the national training and certification programmes in the countries of S.E. Asia. Specialised inspection services were provided to Koyna Hydro Power Station for following up of inherent flaws in the buckets of the peltron wheel. A breadboard model of a pipe gauge for detecting blockages in pipes of dimensions varying from 25mm to 70mm using a single probe has been developed.

Publications

R.L. Ajmera, R.G. Deshpande, A.C. Eapen and S.M. Rao, "Radiotracer applications in Indian industry - A review", *Industrial Applications of Radioisotopes & Radiation*, Proc. Int. Conf. on Application of Radioisotopes & Radiation in Industrial Development, Bombay, March 1-3, 1984; 217-224 (1986).

S.V. Navada, "Our experience on the application of environmental stable isotopes for hydrological studies", Proc. Workshop on isotope hydrology, Dec. 13-14, 1983; 24-40 (1986).

A.R. Nair, "Possibilities of liquid scintillation counting for T & radio carbon measurements in natural waters", *ibid.*, 41-55.

S.M. Rao, 'Injected radiotracer techniques in hydrology", *ibid.*, 157-178.

A.C. Eapen, "Injected tracers in pollution studies", *ibid.*, 198-203.

S.M. Rao and S.K. Jain, "Tracer transport modelling for unsaturated zone - effect of anion exclusion and immobile water", *Isotopen proxis* **21** (1985) 433-438.

"Production and Application of Radioisotopes and Radiation - The Indian Scene", Proc. Int. Symp. on 50 years of Artificial Radioactivity, Pune, January 1985.

V.K. Iya, R.G. Deshpande, R.S. Mani, T.S. Murthy, K. Krishnamurthy and M.V. Ramaniah, "Radioisotope Programme in India - Production & Applications", Proceedings of the South Pacific Conference on Nuclear Power & Applications, Seoul, 1985.

V.K. Iya, "The Industrial Production of Tracers for Use in Nuclear Medicine in India : Current Status & Future Prospectus", Symp. on Radiopharmaceuticals, Indo-American Society of Nuclear Medicine, Bangalore, January 1986.

K.M. Patel and N.G.S. Gopal, "Determination of Radiation Sterilization on the basis of the Number and Type of Microbial Burden", *Indian J. Pharm. Sci.* **47**(*4*) (1985) 163-165.

H.L. Bhalla, M.M. Bapat, K.S. Desai and N.G.S. Gopal, "Radiation Sterilization of Prednisolone", *Indian Drugs* **22**(*10*) (1985) 529-532.

H.L. Bhalla, D. Gosavi, N.G.S. Gopal and G. Sharma, "Radiation - A New Method for Sterilization of Oxytetra Cycline Hydrochloride", *Indian Drugs* **23**(*3*) (1985) 1-5

R.S. Mani, "Radiopharmaceuticals in Cardiology", Proc. National Workshop on Nuclear Cardiology, Department of Medicine, S.M.S. Medical College, Jaipur, 1986 (in press).

R.S. Mani, "Research reactor production of radioisotopes for medical use", Proc. IAEA Int. Conf. on Radiopharmaceuticals and Labelled Compounds, Tokyo, 1985; 3.

R.S. Mani, P. Vanaja, Saraswathi Iyer, N. Ramamoorthy, "Development of a gel type generator for Tc-99m", in *Develoment of Tc-99m generators using low power research reactors*, Report of the IAEA Research Coordination Meeting, Bangkok, Nov. 1985.

R.S. Mani, "Radiopharmacy in Nuclear Medicine", in *Text Book of Nuclear Medicine* (Ed. A.K. Basu), Cosmo Publication, New Delhi, 1986.

R.S. Mani, N. Ramamoorthy, M.K. Das and B.R. Sarkar, "Studies of the medical radionuclides produced by alpha beam at VECC, Calcutta", Abstracts–Workshop on utilization and future programme of VEC Calcutta, 1986.

T. Jyotsna, M.R.A. Pillai, N. Pal, Jyoti H. Gupte, C.N. Desai and R.S. Mani, "Simultaneous assay of triiodothyronine (T_3) and Thyroxine(T_4) in serum", *J. Radioanal. Nucl. Chem.* (articles), **97** (*1*) (1986) 45.

N. Ramamoorthy, S.M. Banodkar, Smita Shetye, Saraswathi Iyer and R.S. Mani, "Studies on the preparation and evaluation of Tc-99m -HIDA Complexes", Proc. DAE Int. Symp. on Artificial Radioactivity, Pune, 1985; PAR-38

G. Samuel, N. Sivaprasad and R.S. Mani, "Preparation of I-125 phenytoin for RIA", Proc. of DAE/BRNS Symp. on Radiochemistry and Radiation Chemistry, IIT, Kanpur, Dec. 1985; 408.

G. Samuel, M.R.A. Pillai, U.K. Singh, C.N. Desai and R.S. Mani, "Radioimmunoassay of Somatotrophin using second antibody PEG separation system", *J. Radioanal. Nucl. Chem.* (articles) **97** (*2*) (1986) 309.

T. Jyotsna, M.R.A. Pillai, Jyoti H. Gupte and R.S. Mani, "Carbodimide used in coupling triiodothyronine antibody to carboxymethyl cellulose powder for solid phase RIA", *Clinical Chemistry* **32** (*1*) (1986)229.

T. Jyotsana, M.R.A. Pillai, Jyoti H. Gupte and R.S. Mani, "Mild radioiodination of insulin with dichloramine T", *Int. J. Applied Radiation and Isotopes* (in press).

T. Jyotsna, M.R.A. Pillai, Jyoti H. Gupte, Nirmala Nair, C.N. Desai and R.S. Mani, "Dichloramine T - a new reagent for the solid phase iodination of protein hormones", Proc. DAE - Int. Symp. on Artificial Radioactivity, Pune, 1985; PAR 42.

N. Ramamoorthy, P. Vanaja, Saraswathi Iyer and R.S. Mani, "Studies on the preparation of Tc-99m generators based on neutron irradiation of metallic molybdates", *ibid.*, PAR-36.

N. Sivaprasad, Kanchan Kothari and R.S. Mani, "Resin talc - TCA test for radioiodinated prolactin", *ibid.*, PAR 37.

M.K. Das, N. Ramamoorthy, B.R. Sarkar and R.S. Mani, "Studies on the optimization of production parameters for some medically important radionuclides using the VEC at Calcutta", *ibid.*, PAR 39.

M.R.A. Pillai, T. Jyotsna, Jyoti H. Gupte, Nirmala Nair, C.N. Desai and R.S. Mani, "Preparation of labelled Insulin using iodogen and iodobeads", *ibid.*, PAR 41.

M.R.A. Pillai, T. Jyotsna, Jyoti H. Gupte and R.S. Mani, "Radioimmunoassay using antibodies chemically coupled to cellulose powder", Proc. DAE/BRNS Symp. on Radiochemistry and Radiation Chemistry, IIT, Kanpur, 1985; 614.

J.H. Gupte, M.R.A. Pillai, T. Jyotsna and R.S. Mani, "Affinity chromatography purification of insulin antibodies", *ibid.*, 617.

S.M. Banodkar, S.V. Shetye, P.M. Pandey, N. Ramamoorthy and R.S. Mani, "Studies on the preparation and evaluation of Tc-99m diisopropyl and other IDA derivatives", *ibid.*, 633.

N. Ramamoorthy, S.M. Banodkar, S.V. Shetye, P.M. Pandey and R.S. Mani, "Studies on the chemistry of Tc dimercaptosuccinic acid complexes", *ibid.*, 638.

M.A. Majali, M. Pimpalkhute and R.S. Mani, "Radioimmunoassay of FSH", *J. Radioanal. Nucl. Chem.* (Letters) **103** (*2*) (1986) 103.

N. Ramamoorthy, M.K. Das, B.R. Sarkar and R.S. Mani, "Production of ^{96}Tc and ^{95m}Tc VIA the ^{93}Nb (α, xn) reactions", *J. Radioanal. Chem.* **98** (*1*) (1986) 121.

N. Ramamoorthy, M.K. Das, B.R. Sarkar and R.S. Mani, "Studies on the production of ^{97}Ru, ^{38}K and ^{34}Cl^{m} at the Variable Energy Cyclotron of Bhabha Atomic Research Centre, Calcutta", Proc. IAEA Int. Conf. on Radiopharmaceuticals and Labelled Compounds, Tokyo, 1985; 107.

6. REACTORS

6·1 Dhruva Reactor

One of the major highlights of the year was the successful commissioning of the fifth research reactor DHRUVA. The reactor attained criticality on August 8, 1985. It is a 100 MW heavy water moderated and cooled thermal neutron reactor completely designed and built in India. The design of the reactor incorporates many new features which were the result of considerable research and development work carried out at Trombay. A number of Indian industrial firms and BARC between them shouldered the responsibility of fabricating all the major components of the reactor such as the reactor vessel, fuelling machines, heat exchangers and coolant circulating pumps. The maximum thermal neutron flux of $1{\cdot}8 \times 10^{14}$ neutrons per cm^2 per second makes DHRUVA one of the high flux research reactors in the world. One batch of radioisotopes produced in DHRUVA for use in nuclear medicine was supplied on October 8, 1985. The reactor was dedicated to the nation by Prime Minister Rajiv Gandhi during his visit to BARC on November 11, 1985.

6·2 Reactor Engineering

The major thrust of the work was in providing engineering R & D support for the 235 MWe and 500 MWe Pressurised Heavy Water Reactor (PHWR) systems, and in commissioning of DHRUVA.

A number of special engineering facilities have been set up for acceptance testing of some of the important pieces of equipment and components of the power reactors under the pressure and temperature conditions prevailing in an operating power reactor. The coolant circulating pump in a PHWR is one of the most critical pieces of equipment and one of the last to be indigenised. The indigenously manufactured coolant pumps to be used in the second unit of the Narora Atomic Power Station were successfully tested and have been sent for installation at Narora. Acceptance testing of the adjuster rod drive mechanisms for both the units at Narora was completed. One of the novel features of the Narora Atomic Power Station would be the use of liquid poison shut off system as the secondary reactor shut down device. The development work needed to finalise the design of this system was completed. The Fuelling Machine Test Facility used since 1974 to test all the nine fuelling machines for RAPS-II, MAPS-I and MAPS-II was extensively used to find solutions to some of the operational problems encountered in the operating power stations. Calibration and testing of the first fuelling machine head for NAPS was started using the newly commissioned testing facility called Integral Thermal Facility. The compatibility of the 22 element fuel bundle with the fuel handling system was evaluated and it was found that the current 19 rod bundles and the new 22 rod bundles cannot be handled by the same fuelling machine without changing the separator assembly.

Theoretical and experimental investigations related to the loss of coolant accident in a PHWR were carried out. A single beam gamma ray densitometer for void fraction measurement was developed. Experiments to study thermosyphon flow in a simulated figure of eight heat transport loop of PHWR were completed. Steady state data generated were compared with the predictions of the computer code developed for this purpose. The agreement was quite good.

Stress analysis of RAPS-I endshield was carried out taking into consideration the current state of cracking. Work on the development of coolant channels made of zirconium-niobium alloy for 235 MWe and 500 MWe PHWRs was carried out. In light of the pressure tube cracking observed in Canadian PHWRs due to displacement of garter springs, the creep behaviour of coolant tubes under conditions of displaced garter springs was investigated, and, in parallel, work was done on the development of devices for in situ repositioning of garter springs.

In order to reduce the heavy water escape from RAPS, some modifications were proposed in the design of the calandria vault pressure relief system. A detailed analysis was carried out to study the impact of these modifications on the calandria vault components. As an alternative solution, a new design of the blow out panel

was also worked out. Tests were carried out to ascertain the acceptability of the new design.

As a part of the commissioning of DHRUVA reactor, a few modifications to piping system and measurement of heat generation in top plenum of calandria were carried out.

Work related to the replacement of feed water spargers at TAPS was completed and a state of readiness to execute this job was maintained. The condition of the nozzles was analysed from the point of view of fracture mechanics.

Considerable work is being done to provide the design and development support needed to finalise the design of the 500 MWe PHWR. Seismic analysis of the reactor building was completed. Other components and systems of the 500 MWe PHWR which were studied in detail with a view to freezing the preliminary design were calandria, end shield, reactor vault, coolant header, liquid poison shut down system, pressurizer and the fuel handling system. Steady state sub channel analysis also was carried out for the coolant channel with 37 element fuel bundles proposed to be used in 500 MWe PHWRs.

Development of fuel handling system for the 500 MWe Prototype Fast Breeder Reactor (PFBR) was taken up. Conceptual design of some of the subsystems was completed and work on testing the design with models is in progress. Thermal deformation behaviour of control rod drive mechanism of FBTR was analysed in detail.

As a part of a research contract with IAEA, the potential growth of installed nuclear capacity with PHWRs working on thorium fuel cycle was investigated. The feasibility and merits of plutonium recycling in RAPS in combination with natural uranium, depleted uranium and thorium were investigated.

One thorium oxide-plutonium oxide fuel cluster is being irradiated in the CIRUS pressurised water loop. Four numbers of modified (7 × 7) fuel for TAPS have been fabricated by Nuclear Fuel Complex and these will be loaded in the reactor during the coming refuelling shut-down.

All the major components of the 2 MW inpile loop in Dhruva, meant for the development of 500 MWe reactor fuel, were installed. Interconnecting piping between various components was completed and was successfully hydro-tested. Instrumentation and electrical works are in progress. For the 150 kW inpile loop meant for irradiation testing of single fuel pins, all the major components have been ordered. Inspection of main loop pumps is in progress.

Instrumentation and power supply work needed for the satisfactory running of all the engineering test facilities was done. Process instrumentation of all the systems for the DHRUVA reactor were commissioned.

6·3 Reactor Analysis

An integrated dynamic model is being developed for Narora Atomic Power Plant. The model includes primary heat transport system coupled with the steam generator. The model will help to find out the control strategies for the steam generator feed water control. The logic and analog models of RAPS-I primary heat transport system and boiler have been completed for incorporation in the Nuclear Power Plant Simulator.

The first phase of the development of a comprehensive computer code for the analysis of Loss of Coolant Accident (LOCA) in Pressurised Heay Water reactors was completed. Fuel management service for TAPS regarding reload pattern, cycle length, shutdown margin, control rod patterns and maximum reactivity at cold condition was provided. Preliminary physics calculations for the 500 MWe PHWR design were carried out.

Scaling laws were developed for peak ground acceleration and response spectral values to arrive at site specific design response spectrum for a seismic design of nuclear power plant components. Spectrum compatible ground motion was generated for structural analysis.

6·4 Experimental Reactor Physics

Physics parameters of interest were measured at DHRUVA reactor during commissioning at various low power levels to determine critical moderator level and absolute fluxes for power calibration, and for the assessment of heat generation rates. Monitoring system for startup of NAPS reactor is being made. Surveillance

techniques by noise analysis were examined to ascertain their suitability for routine use with on-line processing. Shielding measurements with laminar model were made at APSARA. Damage cross sections were determined for radiation damage assessment. Work has been undertaken for developing suitable irradiation conditions for transmutation doping of silicon for BHEL.

6·5 Reactor Control

All the safety, control and monitoring systems of DHRUVA reactor were commissioned and made operational. The automatic power control system of the reactor to permit safe operation at any desired power level was put into service. A modern data handling system with CRT displays to present to the operator reactor sub-system operational status and alarm information on console CRTs, was installed at DHRUVA. Nine shut-off rod drive systems of DHRUVA reactor were fabricated and commissioned. A sequential control system for moving samples for irradiation in and out of the reactor was also made operational.

The 150 kW DC motor drives for primary coolant pumps, and the 65 kW DC motor drives for secondary coolant pumps of FBTR were commissioned.

A microprocessor based channel temperature monitoring system to monitor the outlet temperatures of 306 coolant channels was installed at the Madras Atomic Power Station. The system performs reactor protection functions by computing safety parameters based on channel temperature data and provides alarm annunciation on CRT and on the printer. This system provides the operator with precise information for effective reactor management.

The development and live testing of mechanical shut-off rod drive mechanism for NAPP reactor was completed. Production of shut-off rod assemblies is in progress. A microprocessor based reactor regulating system prototype for NAPP was developed and was fully tested. The system will be used to automatically control the reactor power from a few watts to 230 Megawatts level.

The fuelling machine control system for the Integral Thermal Facility was commissioned and is now capable of operating in semi-automatic mode using a satellite microcomputer. Tests for completely automatic operation of two fuelling machines working in synchronism are being carried out.

6·6 Reactor Operations, Services & Maintenance

The reactors APSARA and CIRUS were operated safely and efficiently. Irradiation testing of thorium oxide-plutonium oxide fuel assemblies for thorium utilization in power reactors, and continued radioisotope production were the main on-going activities. The newly installed solid state control systems of APSARA and CIRUS accumulated more than one year of trouble free operation.

Publications

V. Venkat Raj, "Studies on the Rewetting of Not-Horizontal Surfaces", Ph.D. Thesis, I.I.T. Bombay, 1985.

V. Venkat Raj, D. Saha, P.K. Dolas and S.G. Markandeya, "Some separate effects tests pertaining to LOCA", Indo-German Workshop on Transient Analysis and Emergency Core Cooling Systems, BARC, Trombay, Jan 21 - Feb. 1, 1985.

S.S. Bajaj, R.N. Bhawal, R.B. Grover, S.K. Haware and V. Venkat Raj, "Containment Studies for Indian PHWRs", *ibid.*

M.M. Hanna, G. Ghosh and V. Venkat Raj, "Design of ECCS for PHWRs", *ibid.*

V. Venkat Raj, "Investigations on the Rewetting of Hot Horizontal Channels", *ibid.*

D. Saha, P.K. Vijayan and V. Venkat Raj, "Visualisation of Natural Convection Flow Using Aluminium Particles", *Measurement Techniques in Heat and Mass Transfer,* Proc. Int. Centre for Heat and Mass Transfer, **18**, 1985, 91-102.

S.G. Markandeya, S.K. Dutta and V. Venkat Raj, "Thermal Design Analysis of Transfer Pot for Handling of Spent Fuel from Fast Reactors", Paper No. E 3/5, 8th Int. Conf. on Structural Mechanics in Reactor Technology, Brussels, August 19-23, 1985.

P.K. Vijayan, V. Venkat Raj, S.K. Mehta and A.W. Date, "Phenomenological Investigations on Natural Convection in a Loop Relevant to a PHWR", ASME Winter Annual Meeting, Florida, November 1985.

P.K. Vijayan, D. Saha and V. Venkat Raj, "Natural Convection in Vertical Annulus with Baffles", 8th National Heat Transfer Conference, Andhra University, Visakhapatnam, December, 1985.

P.K. Vijayan, V. Venkat Raj, S.K. Mehta and A.W. Date, "Investigations on Natural Convection in a Figure of Eight Loop", Paper No. 810, *ibid.*

S.K. Mehta, V. Venkat Raj and P.K. Vijayan, "Pressurised Heavy Water Reactor Safety Studies Pertaining to Natural Convection Heat Removal Following Loss of Power and Rewetting of Hot Horizontal Channels", International ANS/ENS Topical Meeting on Thermal Reactor Safety, San Diego, Feb. 2-6, 1986.

P.S. Bandyopadyay, B. Murali, R.K. Singh and H.S. Kushwaha, "Fatigue Analysis of End Fitting Body of PHWR", *F/18-11, SMIRT 8,* Aug 19-23, 1985.

R.K. Singh and H.S. Kushwaha, "Some new ideas for Transient Heat Conduction Analysis", 8th National Heat and Mass Transfer Conference, Visakhapatnam, Dec.,1985.

R.S. Soni, G.R. Reddy, H.S. Kushwaha, and A. Kakodkar, "Seismic Analysis of 500 MWe PHWR and Generation of Floor Response Spectra", Symposium on Vibration of Power Plant Equipments, March,1986.

H.S. Kushwaha, R.S. Soni and A. Kakodkar, "Modelling of Reactor Building in Seismic Analysis", I.A.E.A. Seminar on earthquake, March,1986.

R.S. Soni, H.S. Kushwaha, V.K. Mehra and A. Kakodkar, "Double Thermal Sleeve Interference Fit Design for a BWR Feedwater Nozzle", I.A.E.A. Seminar on Backfittings in Nuclear Plants, Munich, Nov.,1985.

B.K. Dutta, "A Plane Stain Thermo-mechanical Finite Element Model for residual stress determination during welding and annealing", Conf. on Numerical Methods - Theory and Applications (NUME TA), 7-11 Jan., 1985.

B.K. Dutta, B. Murali, W.V. Ramana, H.S. Kushwaha and A. Kakodkar, "Stress Analysis of Plenums and End-Shield of 100 MW Research Reactor", 8th Conf. on Structural Mechanics in Reactor Technology, August 19-23, 1985.

H.S. Kushwaha, B.K. Dutta and A. Kakodkar, "Elast Plastic Analysis of Seal Disc", *ibid.*

S.G. Markandeya, B.K. Dutta and V. Venkat Raj, "Thermal Design Analysis of Transfer Pot for handling of spent fuel from Fast Breeder Reactor", *ibid.*

B.K. Dutta, B. Murali, H.S. Kushwaha and A. Kakodkar, "A new approach to make use of plate elements for nonlinear thermal gradient across thickness", Conf. on Finite Element in Computational Mechanics, 2-6 Dec., 1985.

R. Singh, H.S. Kushwaha and B.K. Dutta, "Seismic Response of Cooling Tower", *ibid.*

B.K. Dutta, H.S. Kushwaha and A. Kakodkar, "Use of Finite Element Techniques for Stress Transient Computation during Welding and Annealing", Symp. on Recent Advances in Welding Metallurgy and Processes, 5-7 Feb.,1985.

B.K. Dutta, W.V. Ramana and H.S. Kushwaha, "3-D Temparature Distribution Computation in Reactor Vault of 500 MWe Nuclear Reactor", 8th Conference on National Heat and Mass Transfer, 29-31 Dec.,1985.

B.K. Dutta and A. Kakodkar, "Analysis of Hydrogen Concentration in Poison Tubes of Dhruva Reactor", *ibid.*

H.S. Kushwaha, B.K. Dutta and R.K. Singh, "Numerical Methods in Solid Mechanics", Workshop on Solid Mechanics, University of Roorkie, 13-16 March,1985.

S.G. Markandeya, B.K. Dutta and V. Venkat Raj, "Heat Transfer Consideration in the Design of Transfer Pot for Spent Fuel Handling of PFBR - A parametric study", Seminar on Fast Reactor Fuel Code, IGCAR, 1985.

R.K. Singh, P.S. Bandyopadhyay, H.S. Kushwaha and A. Kakodkar, "Thermal Shock and Fatigue Analysis of RAPS-1 End Fitting", *BARC/1-822*

Usha Nathan, A.R. Chhokera, D.P. Rao and C.S.P. Iyer, "Parametric Studies on Boron Controls in Nuclear Power Reactors", *BARC/1-852*

M.L. Dhawan, "Gamma-Ray Heating Measurements in Top Plenum of Reactor Dhruva at 1 KW of Reactor Power with Thermoluminescent Dosimeters", *BARC/1-858*

B.K. Dutta, H.S. Kushwaha and A. Kakodkar, "Development of Graphics Computer codes on N D Computers for pre-and post-data processing of finite element computer program", *BARC/1-819*

B. Murali, B.K. Dutta, H.S. Kushwaha and A. Kakodkar, "A report on Stress Analysis of Top Plenum of Dhruva Reactor", *BARC/1-831.*

A.B. Mukharjee and V.K. Mehra, "Parametric study for the design of thermal sleeve", Paper No. *F18/9SMiRT-8,* Belgium, Sept.,1985.

R.R.S. Yadav, V.K. Mehra and A. Kakodkar, "Stress Analaysis of Sleeve Repaired elbow-elbow weld joints", Paper No. *F1 7/10, SMiRT-8,* Belgium September,1985.

K.N. Vyas, "Selection of micro processor based system", Indian Physics Association Seminar, 30 Dec. 1985 - 1 Jan. 1986.

D.G. Belokar, R.B. Grover and V. Venkat Raj, "Design and Development of gamma ray densitometer for void fraction measurement in steady state two phase flow", Conf. on Thermal systems, Varanasi, 1986.

D.P. Rao, "Thermal behaviour of quench tank", 8th Heat & Mass Transfer Conf., Waltair, December,1985.

Usha Nathan, A.R. Chokkera, D.P. Rao and C.S.P. Iyer, "Parametric Studies

on Boron Control in Nuclear Power Stations", *BARC/I-852.*

Salvi Vasan, R.B. Grover and N.M. Nadaph, "Experimental determination of pressure drop in coiled tubes", *BARC/I-861*

V. Jagannathan, "Potential of a New Finite Element Representation for Efficient Analysis of 3-D Reactor Transients", Int. Conf. on Finite Elements in Computational Mechanics (FEICOM-85), IIT, Bombay, Dec. 2-6, 1985.

G. Chakraborty and L.G.K. Moorthy, "Transient Effect of Large Voltage Dips and Change in Grid Frequency on PHWR Primary Heat Transport System", 8th National Heat and Mass Transfer Conference, Andhra University, Vishakhapatnam, Dec. 29-31, 1985.

S.K. Gupta and L.G.K. Moorthy, "Temperature Transients in a Horizontal Reactor Channel under Stratified Cooling Flow Conditions", *ibid.*

A.K. Ghosh and L.G.K. Moorthy, "Analysis of Two-Phase Critical Flow by a U-V-U-T Model", *ibid.*

L.G.K. Moorthy and A.K. Ghosh, "Thermal Hydraulic Problems in Indian Pressurized Heavy Water Reactor Safety", *ibid.*

K.R. Srinivasan *et al.*, "Multidimensional Core Kinetics Analysis of LWRs and PHWRs", Indo-German Workshop in Transient Analysis and ECC Systems, BARC, Bombay, January, 1985.

S.S. Joshi, K.K. Arora and R.V. Koparde, "Comparative Study of Measurement Techniques for Coolant Transit Times in a Boiling Water Reactor using Noise Signals of LPRMs", *Progress in Nuclear Energy* **15** (1985) 921.

S.S. Joshi, K.K. Arora and R.V. Kaparde, "Applications of Noise Analysis made at Tarapur Atomic Power Station (BWR) for Vibrations, Transit Time, Coolant Flow Rate in the Recirculation Loop using ^{16}N Signal; and Neutron Noise Measurements at Madras Atomic Power Station (PHWR)" *Progress in Nuclear Energy* **15** (1985) 939.

S.S. Joshi, K.K. Arora and R.V. Koparde, "Applications of Neutron Noise Analysis made at Tarapur Atomic Power Station (BWR) for the Core Internal Vibrations", Proc. of National Symp. on Vibration of Power Plant Equipment, BARC, March, 1986.

A.H. Mistry, S.L. Mehta and L.R. Ramaswamy, "Dedicated Microprocessors for Reactor Physics Experiments", *RG/ERPS/NOTE/131/85.* May, 1985.

R.V. Koparde, S.S. Joshi and K.K. Arora, "Microprocessor Based Approach to Criticality of DHRUVA", *RG/ERPS/NOTE/132* September, 1985.

S.S. Joshi, K.K. Arora and R.V. Koparde, "Microprocessor Based Approach to Criticality at NAPP-I", *RG/ERPS/NOTE/133* December, 1985.

S.S. Joshi, K.K. Arora and R.V. Koparde, "Coolant Flow Rate Measurements in the Recirculation Loop of TAPS Unit No. 1", *RG/ERPS/NOTE/135* December, 1985.

S.L. Mehta, A.H. Mistry, C.S. Gopalkrishnan and L.R. Ramaswamy, "Measurements of Thermal Neutron Flux Distributions at Various Core Locations and at Different Elevations in the Top Plenum of Calandria during Phase-B Commissioning of DHRUVA Reactor", *RG/ERPS/NOTE/134/86,* February, 1986.

7. FUEL CYCLE

7·1 Ore Dressing

The major thrust of the studies carried out centered on maximising the recovery of uranium from the tailings of copper plants in Singhbhum and on the feasibility of employing beneficiation techniques for exploiting low grade uranium ores. An integrated gravity beneficiation flow-sheet to substantially improve the existing recovery of uranium values from tailings of Mosabani, Surda and Rakha copper plants, in Singhbhum was developed. Laboratory scale continuous pilot plant tests have given a recovery factor of more than 45% from Mosabani tailings and over 65% from Rakha and Surda tailings. These recoveries are respectively 100% and 50% improvements over the performance of existing procedures. Encouraged by the results a pilot plant was set-up at Mosabani plant site and large scale tests (4-6 TPH) were carried out in association with UCIL, to facilitate techno-economic decisions on the implementation of the recommended flow-sheet. Experiments were carried out using the integrated flow-sheet on low grade uranium ores from Jaduguda, Narwapahar and Turamadih in Singhbhum. Preliminary results obtained are encouraging. Considerable work has been carried out on the recovery of another strategic material tungsten by beneficiation.

Tests carried out on a low grade wolframite ore from Degana in Rajasthan containing 0·013% tungsten oxide has shown that it is possible to increase the concentration to 10%. Further upgradation to marketable grades can be attempted by chemical methods. The process will facilitate extensive exploitation of low grade tungsten deposit at Degana, Rajasthan. At the request of M/s. Hindustan Copper Limited, extensive studies have been conducted on Malanjkhand Copper Ore with a view to improving the existing copper recovery at the Malanjkhand Copper Concentrator. Detailed mineralogical and liberation studies have indicated the presence of a number of copper minerals, both in sulphide and oxide forms, which have different flotation characteristics. Studies have shown that copper recovery exceeding 95% is possible with some modifications in the existing process. Fundamental studies in different aspects of mineral beneficiation and petromineralogy were also carried out.

7.2 Uranium Metal Production

The project for the expansion of the uranium metal plant has been completed with the commissioning of all the sections of the plant,and uranium metal of nuclear purity was produced and made available for fabrication of nuclear fuel for CIRUS and DHRUVA reactors. After carrying out development work on the recovery of uranium from the leach liquors obtained from slag processing, the process has been applied on plant scale.

7·3 Uranium Fuel Fabrication

The natural uranium fuel fabrication facility fabricated and supplied to CIRUS reactor 167 metallic uranium fuel elements (X-rods), about 3700 X-rod components and 3 cobalt slug J-rod assemblies. For DHRUVA reactor 29 metallic uranium fuel clusters, 3 tray rods, one pneumatic carrier rod and aluminium shields were supplied. More than 250 nitrided power reactor components, 1265 zirconium-niobium-copper alloy garter springs and 14 intricate zircaloy guide tubes for mechanical shut-off rods and one in-core flux mapping tube for NAPP were fabricated and supplied.

With a view to achieving higher burn-up and to reduce the number of steps in the fabrication of metallic uranium fuel, work was carried out to develop hollow uranium rods by extrusion and rolling, segmented uranium rods, multimould castings of uranium and X-rods of adjusted uranium. One cluster made out of adjusted uranium and another made out of multi-mould casting of uranium were fabricated and supplied to CIRUS for in-pile tests. The behaviour of these fuel rods in the pile is considered to be quite satisfactory.

Development Work

Low temperature sintering of natural uranium oxide fuel fabrication technology has been developed and 100 kg of UO_2 pellets were produced. Experimental PHWR bundles will be made for trial irradiation. Preparations are in progress for fabrication of plate type fuel for the neutron source reactor at Kalpakkam.

Development work was also continued on full

length welding of bearing pads and spacers on zircaloy fuel sheaths for improved performance of PHWR fuel bundles, clad ballooning experiments and on electropolishing of zircaloy tubes. To minimize pellet-clad interactions and to improve performance of BWR fuel, development of zircaloy tubes with an inner layer of zirconium was also undertaken.

An engineering scale semi-continuous facility was set up and successfully operated for the preparation of 500 g per day uranium oxide microspheres by sol-gel process.

Quality Assurance

Quality surveillance work on fuel bundles, zircaloy components and core assembly components meant for PHWRs and BWRs, fuel pins and fuel cluster assemblies for FBTR, LPRMS for TAPS, SS sheets for HWP etc. were carried out. Against specific requests from other DAE units and outside agencies, material evaluation, specialised non-destructive tests, heat treatment, machining, welding, rolling, extrusion and drawing of various materials were undertaken.

7·4 Plutonium Fuel Fabrication

Mixed Carbide Fuel for FBTR

On standardising various production parameters, required quantity of the mixed carbide fuel pins for FBTR was manufactured using all indigenous materials and then transported to the reactor site at Kalpakkam. This fuel has a uniqe composition developed for the first time in the world. It is also the first time in the world that a mixed carbide fuel manufacture programme of this magnitude has been succesfully accomplished. Valuable technical data were collected on the characteristics of the fuel during the fabrication process.

MOX Fuel

Civil engineering works on the MOX fuel manufacturing facility at Tarapur, have been completed except for finishing works. Work on electrical, ventilation and other services is in progress as per schedule. The setting up of plant equipment in glove boxes is in progress.

Post-Irradiation Examination

The post-irradiation examination of the experimental MOX fuel pin clusters, successfully irradiated in CIRUS reactor, was started and useful data were gathered. Computer predictions of the performance parameters were also made and experimentally verified. The results indicate good co-relation.

Several irradiated components received from RAPS and TAPS were subjected to extensive metallurgical investigations. Experimental DHRUVA reactor fuel elements were examined to assess the behaviour of the fuel elements and for improved design inputs. Useful data were generated with respect to coolant channel materials. Under an IAEA research co-ordinated programme, impact testing of different pressure vessel materials, after irradiation at CIRUS, was carried out to determine the changes in the nil ductility transition temperature and other properties. The data generated matched well with the results of other laboratories in the world.

7·5 Fuel Reprocessing

The Plutonium Plant at Trombay continued to reprocess the fuel discharged from the research reactor CIRUS. The data on plant performance particularly from the reprocessing of shorter cooled fuel considered to be troublesome was collected and analysed for making further changes in the reprocessing scheme. During the year the spent fuel storage pond was completely emptied, the accumulated high active solids were removed, the pool surfaces washed and recommissioned.

The Power Reactor Fuel Reprocessing Plant at Tarapur completed the third safeguarded campaign of reprocessing the spent fuel from RAPP. The performance was highly satisfactory and product specifications were met. During the maintenance outage that followed, the cell equipments were decontaminated to bring down the levels for inservice inspection and effecting certain changes. An additional ion exchange cycle was introduced with the necessary interlocks. The spent fuel from MAPP was transported by rail and received in the fuel storage pond in the plant. The plant operation was restarted.

In the Kalpakkam Reprocessing Plant, construction

of main and allied buildings, procurement of bulk materials like stainless steel plates and pipes and major mechanical and electrical equipments, and fabrication of certain complex process vessels and components are making satisfactory progress.

Because of high density of piping in the process cells and the piping layout itself being quite complex involving hundreds of interferences, computer-aided design is used for preparing piping layout drawings. A software package has been developed for routing of the pipes in the process cells. A computer aided Management Information System (MIS) has also been developed for monitoring the physical and financial progress of the project during the execution stage.

Work on the setting up of the Operation Test Facility (OTF) for process simulation studies and equipment testing has been completed. Experiments have been started on the determination of pulsing characteristics under dynamic conditions. Mock-up studies were carried out on the syphon system in the caustic scrubber, where continuous recirculation is required to be maintained, to obtain a positive indication of flow and flow rate. Efforts are being made to use this technique for measurement of flow rates of process streams also. Computer is extensively used in the design calculations, flowsheet simulation, analysis of performance of operating plants, data acquisition, project management etc.

A project proposal has been submitted for setting up an engineering scale facility for reprocessing irradiated thorium fuel from CIRUS and DHRUVA in order to separate U-233. The financial sanction is awaited.

7·6 Radioactive Waste Management

Construction of the Solid Storage Surveillance Facility (S3F) at Tarapur, meant for interim storage of solidified high level radioactive waste packages produced in the Waste Immobilisation Plant (WIP) at Tarapur, has been completed. Commissioning tests and installation of process equipment are nearing completion. The facility is expected to be in operation by the middle of 1986. Hot Cells associated with S3F meant for product evaluation and characterisation are expected to be commissioned by the end of 1987. Design of Waste Immobilisation Plant already sanctioned by the Atomic Energy Commission and meant to handle the highly radioactive waste generated in the expanded Plutonium Plant at Trombay is at an advanced stage. This plant is estimated to cost about Rs. 38 crores. Civil engineering works related to the Waste Management Plant designed for treatment of radioactive waste generated in the NAPP is nearing completion. Erection of equipment and piping is progressing on schedule and the facility is expected to be commissioned six months prior to the start of power plant operation. Work on the design of a plant to augment the facilities for immobilisation of spent ion exchange resins at Tarapur has been started. Detailed cost estimates based on a revised design of the Alpha Waste Management Facility (AWMF) proposed to be built at Kalpakkam is under preparation. A plant for regenerating the alkali contained in the effluent from Zirconium Oxide Plant of Nuclear Fuel Complex at Hyderabad was installed. Operating experience from this plant will provide data for designing a larger plant.

Facilities for management of radioactive wastes and chemical effluents at Tarapur, Rajasthan, Trombay, NFC at Hyderabad, IRE at Alwaye, ECIL at Hyderabad and at Kalpakkam functioned satisfactorily. Information gathered from the operation of these facilities is expected to provide feed back for designing future radioactive and effluent management facilities.

Various glass compositions with promising characteristics as a matrix for fixing high level radioactive waste were identified as a part of continued R & D work. Investigations are being carried out on the suitability of a number of materials as chemical barriers in radioactive waste repositories. As a part of the on-going field evaluation of deep geological formations for radioactive waste disposal, an array of bore holes were drilled at a depth of 1 km in an abandoned mine chamber in order to conduct thermo-mechanical experiments. Electrical heaters, thermocouples and other necessary instruments have been installed for simulating radioactive decay heat, and for observing the associated thermo-mechanical effects. The effect of such heaters was simulated using a computer, and the experimental data will be used to verify the computer simulation. R & D work related to decontamination of nuclear facilities was also continued.

Publications

N.P.H. Padmanabhan, Ch. Rambabu, Pradip and G.V.U. Rao, "Processing of low grade wolframite ore from Degana, Rajasthan", Int. Conf. in Metallurgical Research: Fundamental and Applied Aspects, IIT, Kanpur, Feb.,1985.

R.S. Jha, H. Singh, R. Natarajan, U. Sridhar, Ch. Rambabu and G.V.U. Rao, "Investigation on gravity concentration of uranium fines", *ibid.*

S.K. Shukla, R. Natarajan, K.K. Das, R.R. Venkitakrishnan, N.P. Subrahmanyam and N.K. Rao, "Improving scheelite recovery from gold tailings", National Seminar on Mineral Processing, NML, Jamshedpur, March,1985.

Ch. Rambabu, "Developments in phosphate-rock beneficiation and the problems with Indian phosphorites", *ibid.*

R. Natarajan, R.S. Jha, K.K. Das, U. Sridhar, H. Singh, Ch. Rambabu and N.K. Rao, "Large scale experiments at BGML (Kolar) on beneficiation of uranium values from Mosaboni copper tailings", Report submitted to UCIL, Feb.,1985.

H. Singh, N.P.H. Padmanabhan and N.P. Subrahmanyam, "Laboratory investigations on improving the recovery of rutile from Chavara sands by optimising performance of dry mill of IRE, Chavara", Report submitted to IRE, March,1985.

H. Singh, R.S. Jha, R. Natarajan and N.K. Rao, "Feasibility of improving uranium recovery from Mosaboni copper tailings by gravity beneficiation", Report submitted to UCIL, May, 1985.

H. Singh, S.K. Shukla, R.S. Jha, R. Natarajan, D. Narasimhan, K. Sivaramakrishnan, G.E. Prasad and N.K. Rao, "Laboratory investigation on improving the recovery of cabalt and nickel values in Mosaboni copper concentrator of Hindustan Copper Limited. Part I. Ore Dressing Studies; Part II. Petrographic Studies", *BARC/R : 4*

H. Singh, R.S. Jha, M. Manmadha Rao, D. Narasimhan, Ch. Rambabu and N.K. Rao, "Development of Gravity Concentration Process for chromite recovery from ores of Orissa Mining Corporation", *BARC/R : 5*

H. Singh, R.S. Jha, R. Natarajan, K.K. Das, U. Sridhar, M. Manmadha Rao and N.K. Rao, "Development of a Gravity Concentration Process for improving uranium recovery from copper tailings", *B.A.R.C/I-853.*

K.K. Das, R. Natarajan, V.H. Bafna, K. Sivaramakrishnan, N.V. Iyer and N.K. Rao, "A preliminary report on the removal of selenium from the effluents of selenium plant, NFC", Report submitted to NFC, July,1985.

S.K. Shukla, N.P.H. Padmanabhan, M. Manmadha Rao, N.P. Subrahmanyam, R.R. Venkitakrishnan and N.K. Rao, "Beneficiation of low grade wolframite ore from Degana, Rajasthan", Report submitted to Rajasthan State Tungsten Development Corporation Limited, Sept.,1985.

H. Singh, V.H. Bafna, R. Natarajan, R.S. Jha, U. Sridhar, Ch. Rambabu and N.K. Rao, "Uranium recovery by improved gravity concentration process incorporating Bartles Machines-Bartles Mozley Separator and Bartles Cross Belt Concentrator", Report submitted to UCIL, Sept.,1985.

K. Raj and M.T. Samuel, "Modified Pot Glass Process for Vitrification of High Level Radioactive Waste - Process Engineering Aspects", XIV International Congress on Glass, Delhi, 2-7 March, 1986.

G.A. Vaswani and P.B. Jahagirdar, "Formulation and Characterisation of Borosilicate Glass for immobilising Highly Radioactivity Wastes", *ibid.*

Satya Brat, "Synthetic Mg-Al-Na Silicates in Radioactive Waste Management", *Indian Journal of Technology* **23** (1985).

D.S. Deshingker, K.G. Gandhi and S. Ramachandran, "Development of a cartridge for monitoring of inorganic forms of radioiodine from stack gases of boiling water reactors", *BARC/I-864.*

P.M. Markose, M. Raghavayya and K.C. Pillai, "Leachability of radium from uranium mill tailings", *J. Water, Air and Soil pollution* **26** (1985) 95-104.

S. Venkataraman, "Uranium and radium-226 in wells around the uranium complex at Jaduguda", XII Ann. Conf. of IARP, Bombay, March 18-21, 1985.

K.P. Eappen, P.M. Markose and K.C. Pillai, "Fractionation of radionuclides in acid-leach process of uranium ore", *ibid.*

G.K. Srivastava, A.H. Khan and M. Raghavayya, "Utility of low level radon detection system", *Bull. Rad. Prot.* **8**(*2*) (1985).

G. Jha and M. Raghavayya, "Calibration of cellulose nitrate film for measurement of time-integrated concentration of radon in air", IV National Seminar Cum Workshop on SSNTD, Dehra Dun, Nov. 4-6, 1985.

G.K. Srivastava, M. Raghavayya, P. Kotrappa and S. Somasundaram, "Systemic Radium-226 body burden of uranium mines by measurement of radon in breath", *Health Physics Journal* (in press).

A.H. Khan and M. Raghavayya, "Annual Report for 1984 of Health Physics Unit, UCIL, Jaduguda (Bihar)", *BARC/I-824*

R.T. Kulkarni, S.S. Pandit, A. Mukherji and A. Ramanujam, "Extractive Spectrophotometric Determination of Uranium with 1 - (2 - Pyridylazo) - 2 Naphthol (PAN) in Purex Process Streams", DAE Symp. on Radiochem. and Radiation Chem., CT-24, IIT, Kanpur, December,1985.

A. Ramanujam, V. Gopalakrishnan, J.A. Kazi and R.S. Dhami, "Remote Aliquoting of Highly Radiactive Samples in Purex Process", *ibid.*, CT-25

T.S. Laxminarayanan, K. Vijayan, A. Ramanujam, V. Gopalakrishnan and P.S. Dhami, "Direct Photometric Monitoring of Uranium (IV) Content in Electrolyser Stream and Plutonium Content in Plutonium Product Stream of Purex Process using Mettler Phototrode DP 660", *ibid.*, CT-26.

S.C. Tripathi, A. Ramanujam, M.N. Nadkarni, K. Annaji Rao and C. Bandyopadhyay, "Chromatographic Assay of Degradation Products of Tributyl Phosphate", *BARC-1272* (1985).

I.A. Siddiqui, et al., "Process Dynamics Studies in Pulsed Solvent Extraction Column", Nat. Symp. on Solv. Ext., Anna Univ., Madras, 1985.

S.V. Kumar, M.K.T. Nair and V.R. Raman, "Application of Pulsed Solvent Extraction Columns in Spent Nuclear Fuel Reprocessing", *ibid.*

R.P. Raju, et al., "Application of Optimisation Techniques in the Design and Operation of Fuel Reprocessing Plants", Seminar on Fast Reactor Fuel Cycle, Kalpakkam, Feb. 10-12, 1986.

V.V.S. Mani, R.K. Singh, A.D. Moorthy, R.R. Chandrasekhar, U.S. Kolte, P.B. Gurba and R.K. Babbar, "Field Experience in the Use of Low Burn up Plutonium as a Spike Tracer in the Estimation of Plutonium in Power Reactor Fuel Dissolved Solution by IDMS", Mass Spectrometry Symposium, Regional Research Lab., Hyderabad, September, 1985.

R.K. Singh, A.D. Moorthy, B.R. Chandrasekhar, U.S. Kolte, P.B. Gurba and R.K. Babbar, "Simultaneous Estimation of Uranium and Plutonium in Fuel Reprocessing Plant's Input Solution by IDMS", *ibid.*

R.K. Singh, A.D. Moorthy, R.R. Chandrasekhar, U.S. Kolte, P.B. Gurba and R.K. Babbar, "Natural Uranium as an Alternative Spike Material for the Determination of Uranium Content in the Spent Fuel Dissolved Solution by IDMS", *ibid.*

N. Varadarajan, K. Perumaul, George Thomas and K.K. Gupta, "Methods for Fast Determination of Plutonium in Purex Process Solutions", DAE Symposium on Radiochemistry and Radiation Chemistry, IIT, Kanpur,

December,1985.

A.D. Moorthy, R.R. Chandrasekhar, U.S. Kolte, P.B. Gurba, R.K. Babbar and S.V. Udagatti, "Computed Isotope Dilution Alpha Spectrometry for the Determination of Plutonium in the Input and Waste Discard Samples of a Reprocessing Plant (CIDAS)", *ibid.*

M.K. Rao, S.V. Kumar and A.N. Prasad, "Reprocessing of Thermal Reactor Fuels and the Kalpakkam Reprocessing Plant", Seminar on Fast Reactor Fuel Cycle, Kalpakkam, Feb. 10-12, 1986.

8. HEALTH AND SAFETY

8·1 Health Physics

Detailed radiation surveys were conducted during commissioning of Dhruva reactor and Linac facility at BARC, and MAPP-II and FBTR at Kalpakkam. The radiation exposures in various DAE facilities were analysed and found to be within the permissible limits. About 3,000 radiation workers were monitored by whole-body counting and bioassay and in all cases the internal exposures were found to be well below the permissible limit. At RAPP and MAPP, internal exposure from tritium was below that of the previous years. Members of public from the critical group were also monitored at power station sites and no significant exposure attributable to power station operation was detected. Environmental surveillance at different DAE installations showed, as in previous years, that there is no significant contribution of radioactivity due to operations carried out at the site. Measurements in the surrounding areas upto a distance of 10 kms showed no increase in background radiation due to nuclear operations. The accident prevention programme, which covers all industrial type accidents, showed that safety standards in BARC were maintained at a high level as in the past.

The programme of measurement of external background radiation throughout the country was completed by taking the measurements at 214 stations spread over different parts of the country. The natural background radiation was found to be the lowest in the basaltic areas as in Maharashtra, and high in the granitic areas as in Andhra Pradesh and Bihar. In the field of micrometeorology, study of heavy gas dispersion has been undertaken in order to assess the potential consequences of releases of heavy gases like hydrogen sulphide, chlorine, etc. A passive dosimetry system was developed at the Health Physics Unit at Jaduguda for assessment of exposure to radon daughter products.

8·2 Radiological Protection

Implementation of radiation safety programme in about 2500 institutions in India using radiation sources for application in medicine, agriculture, industry and research was continued. Personnel monitoring service was provided to 31,500 radiation workers. A system to electrochemically etch plastic detector foils was developed for fast neutron personnel monitoring. Radiological protection surveys were conducted in 210 medical, research and industrial institutions. Eighty medical diagnostics, therapy and nuclear medicine departments, and twenty industrial radiography installations were given authorisation and approval. Development of special measuring instruments for protection monitoring, cancer therapy and dosimetric research was continued. Dosimeters were supplied to various institutions using radiation sources. A scanning densitometer for beam distribution studies in radiotherapy and a microprocessor based secondary standard dosimeter for measurement of X-ray and cobalt-60 beam output were developed. About 70 radiotherapy institutions including a few from Sri Lanka and Burma participated in an intercomparison study for checking the output from their machines. Fifteen nuclear medicine departments using Iodine-131 participated in a radioactivity quality assurance programme. BARC maintains primary dosimetry and radioactivity standards and calibrated several types of instruments referred to it from various institutions in the country. It is currently associated with a scheme initiated by the Department of Science & Technology to evolve a National Measurement System in order to promote uniformity and improve accuracy of measurements.

Countrywide environmental monitoring for natural and fall-out radionuclides was continued. Characteristics of radiolytic aerosols were studied for evaluating radionuclide inhalation dose to workers in uranium mines. Two new programmes on indoor radiation environment study and monitoring of non-ionising radiations were initiated during the year.

Samples, fly-ash, coal and slag around a thermal power plant were assessed for their natural radioactivity content. The know-how for plutonium-in-air monitor was developed. A microprocessor based multipollutant air monitor station was installed in Bombay for routine monitoring. This sytem automatically monitors and records important gaseous products like oxides of

nitrogen and sulphur, ozone and carbon monoxide. The know-how of several instruments and systems developed was transferred to ECIL and other establishments for large scale production.

8·3 Radiobiology and Occupational Health

The technique of flow cytometry was employed for the evaluation of testicular biopsies in male infertility studies. The studies indicate that flow cytometric analysis provides more rapid quantitative analysis of the specimen as compared to conventional cytological examinations. Further, the technique also facilitated detection of karyotypical abnormalities in spermatozoa in some of the specimens.

Studies on alloantigen expression in syngenic tumours gave some new results. Cell culture facility was established for maintenance and cryopreservation of some important cell lines. Antilymphocytic sera (ALS) with selective immunosuppressive action elicit interest because of their potential clinical application. A new ALS that can prolong allograft survival in mice was prepared. Gamma radiation has been shown to induce suppression of delayed hypersensitivity. The degree of suppression was found to depend on the magnitude of the dose and time of point of irradiation with respect to time of sensitisation. The cell transfer studies indicate that radiation causes lymphopenia as a result of which very few number of effector cells are developed. The effector function of these cells, however, is found to be impaired by radiation.

Cytogenetic monitoring of newborn infants has been undertaken to study the incidence of constitutional chromosomal anomalies and its time trend progression. Two hundred and sixty cord blood samples from 140 male and 120 female infants have been screened so far.

The frequency of chromosomal aberrations in peripheral blood lymphocytes has been shown to be a reliable parameter to estimate equivalent whole body exposure dose in accidental exposures or suspected over-exposures to radiation. Such studies were carried out in 44 cases belonging to industrial and medical applications of radiation and to nuclear industry. The studies indicate low incidence of exposure of all the persons.

8·4 Monazite Survey Project

This project is concerned with the evaluation of the detrimental effects of the relatively high natural background radiation on human populations residing in the monazite bearing areas of Kerala. The results obtained so far do not indicate any adverse consequences. The work is being continued.

Publications

P.K. Narayan, R.K. Mathur, V.B. Godse and N.S. Sunder Rajan, "Thermal model of in-situ experiment of 32nd Level Mysore Mine, KGF (Report No. 1)", *B.A.R.C.-1273* (1985).

M.M. Adtani, Bhoja Shetty and S.J. Supe, "Conversion factors for evaluation of effective dose equivalent for reactor personnel", *Radiation Protection Dosimetry* **11**(3) (1985) 159.

S.K. Gupta, R.K. Kher and S.J. Supe, "External bremsstrahlung contribution to the absorbed dose in $CaSO_4$: Dy discs used for personnel monitoring by complete absorption of β rays in the photon energy compensating filter", *Bull. Radiat. Prot.* **9**(1-2), (1986) 49.

R.V. Dhond, R.L. Pandey, K.S. Shenoy, P.H. Patel and S.J. Supe, "Incidences of excessive exposures to industrial, medical and research radiation workers in India (1978-83) and their investigations", *ibid.*, **8**(1), (1985) 15.

R.L. Pandey, P.H. Patel and S.J. Supe, "Analysis of excessive exposures received by radiation workers in medicine, industry and research organizations", *ibid.*, **9**(1-2), (1986) 99.

M. Thomas, R.L. Pandey, P.H. Patel and S.J. Supe, "Dose density response and latent image fading in Kodak Type-2 personnel monitoring films in a water proof plastic packing", *ibid.*, 53.

K.S. Kini and T.V. Venkateswaran, "Exposure of fingers while handling a solvent extraction type Tc^{99m} generator", *J. Nucl. Med.* **26**(6),(1985) 650.

Geetha Sadagopan and T.V. Venkateswaran, "Radiation dose to patients during radionuclide and X-ray diagnostic investigations", *AMPI Med. Phys. Bull.* **10**(3), (1985) 109.

B.L. Gupta and G.R. Narayan, "G (Fe^{3+}) values in the FBX dosimeter", *Phys. Med. Biol.* **30** (1985) 337.

B.L. Gupta and U. Madhvanath, "G (Fe^{3+}) values in the FBX dosimeter at low dose-rates", *Int. J. Appl. Radiat. Isotopes* **36** (1985) 985.

B.L. Gupta, R.M. Bhat, G.R. Narayan and S.R. Nilekani, "A spectrophotometric read out method for free radical dosimetry", *Radiat. Phys. Chem.* **26** (1985) 647.

B.L. Gupta and S.R. Nilekani, "A new technique for the dosimetry of low energy electrons", *Bull. Radiat. Prot.* **8** (1985) 29.

B.L. Gupta, R.M. Bhat, G.R. Narayan and S.R. Nilekani, "Oxidation of ferrous ions by irradiated solid amino acids", Proc. Radiochem. Radiat. Chem. Symp. IIT, Kanpur, 1985; 296.

B.L. Gupta, "Radiation Chemistry of xylenol orange in aqueous solutions", *ibid.*, 299.

B.L. Gupta and R.M. Bhat, "Calibration of high-dose radiation facilities (Handbook)", *BARC-1303* (1986).

M.A. Prasad and K. Unnikrishnan, "A symptetically exact solution of the one dimensional trapping problem with correlation", *Phys. Rev. A* **31** (1985) 523.

K. Unnikrishnan and M.A. Prasad, "Occupancy time for correlated random walks with partially absorbing boundaries", *Acta Physics Austriaca* **56** (1985) 253.

K. Unnikrishnan and M.A. Prasad, "Eikonal expansion for inelastic scattering", *J. Phys. B* **18** (1985) *L* 699.

S.K. Gupta and M.A. Prasad, "A different approach for the application of the Monte Carlo methods to electron transport", *Nucl. Sci. Eng.* **90** (1985) 252.

Bhuvan Chandra, S.S. Shinde and R.C. Bhatt, "Comparative dosimetric studies of three low Z phosphors", *Bull. Radiat. Procl.* **8**(1) (1985) 33.

Bhuvan Chandra, A.R. Lakshmanan and R.C. Bhatt, "Incompatibility of radiation induced sensitization and re-estimation at low absorbed doses in LiF (TLD-100)," *Nucl. Tracks* **10**(1) , (1985)77

Bhuvan Chandra, S.S. Shinde, A.R. Lakshmanan and R.C. Bhatt, "Effect of Li doping on the thermoluminescence response of $CaSo_4$:Dy phosphor", First National Seminar on Defects in Insulating Solids, R.I.T., Jamshedepur, 6-8 Nov., 1985; DOP-17 (Abstract).

A.S. Pradhan and R.C. Bhatt, "Phototransfer thermoluminescence and thermal quenching in $CaSO_4$:Dy", *Nuclear Tracks* **10** (1985) 101.

A.S. Pradhan and R.C. Bhatt, "Dose dependence of phototransfer thermoluminescence in $CaSO_4$:Dy", *J Phys. D : Appl. Phys.* **18** (1985) 317.

A.S. Pradhan, J. Rassow, P. Meissner and K. Olthoft-Muenter, "Additivity of fast neutron and gamma ray induced thermoluminescence and reusability of CaF_2:Tm (TLD-300) ribbons," *Int. J. Appl. Radiat. Isot.* **36** (1985) 103.

A.S. Pradhan, J. Rassow and P. Meissner, "Dosimetry of fast neutron beams using $CaSO_4$: Dy (TLD-900) pellets", *Nucl. Instrum. Meth. in Physics Research* **236** (1985) 396

A.S. Pradhan, J. Rassow, K. Othoff-Muenter, W. Baumhoer and P. Meissner, "In-Phantom dosimetry using CaF_2 : Tm (TLD-300) ribbons", *Int. J.* Appl. *Radiat. Isot.* **36** (1985) 619

A.S. Pradhan and J. Rassow, "A thermoluminescence method for dosimetry of therapeutically used d(14) + Be neutron beams using sulphur activation in $CaSO_4$: Dy (TLD-900) pellets", Proc. Deutrsche Gesellschaft Medizinische Physik, Neuherberg, West Germany (Edited by T. Schmidt), (1985) 151

A.S. Pradhan, J. Rassow and P. Meissner, "Dosimetry of d(14) + Be neutrons with the two-peak method of LiF-TLD-700", *Phys. Med. Biol.* **30** (1985) 1349.

J. Rassow, J.J. Broerse, R. Duhr, F.W. Hensky, S. Marquiberueg, K. Olthoff Muenter, A.S. Pradhan, A. Temme, S. Vynekier and J. Zoetelief, "Spectral dependence of response coefficients and applicability of the two-peak TLD- method in mixed-neutron photon radiation fields", Proc. 5th Symp. on Neutron Dosimetry, G.S.F., Neuherberg, West Germany (Ed. G. Burger), 1985; 783.

A.R. Lakshmanan, Bhuvan Chandra, R.C. Bhatt, W. Hoffmann and R. Spallek, "Thermoluminescence studies in LiF dosimeters irradiated at 77K and its implications on theoretical models", *J. Phys. D : Appl. Phys.* **18** (1985) 1673.

A.R. Lakshmanan, Bhuvan Chandra and R.C. Bhatt, "Thermoluminescence studies in LiF dosimeters irradiated at 77K", First National Seminar on Defects in Insulating Solids", R.I.T., Jamshedpur, 6-8 Nov. 1985 (DRI-5) (Abstract).

S.C. Misra, P.S. Rao, Suresh Rao and A.K. Mahant, "Measurement of the characteristics of vanadium self-powered neutron detectors", *B.A.R.C/I-850*.

D. Sharma, M.G. Shahani, U.V. Phadnis, B.K. Kamboj and S.K. Sadavarte, "14 MeV neutron flux measurement using Fe-56 and the international intercomparison", 6th National Symposium on Radiation Physics, March 3-6, 1986; Abstract No. C-62.

B.K. Kamboj, M.G. Shahani, U.V. Phadnis and D. Sharma, "Indium as secondary standard for 14 MeV neutrons", *ibid.*, Abstract No. C-63.

U.V. Phadnis, B.K. Kamboj, M.G. Shahani and D. Sharma, "An improved thermal neutron flux density standard for the calibration of large detectors", *ibid.*, Abstract No. C-64.

O.P. Massand and U.B. Tripathi, "Some neutron measurements at 15 MV CLINIC-20", *Bulletin of Radiation Protection* **8**(*1*) (1985) 73.

O.P. Massand, H.K. Kundu, M.P. Dhairyawan and P.K. Marathe, "Fast neutron personnel monitoring", Report *BARC/DRP/FNM1* (1985).

P.K. Marathe, G. Unnikrishnan and D. Krishnan, "Comparison of fast neutron RBE values based on the old and revised atom bomb dosimetry", *Bulletin of Radiation Protection*, **8**(*1*) (1985) 21.

M.P. Dhairyawan, G. Venkataraman and O.P. Massand, "Implication of recent ICRP recommendations on neutron monitoring", *ibid.*, **9**(*1-2*) (1985) 95.

Gouri Unnikrishnan and D. Krishnan, "Risk of leukemia from low-LET radiation - upper and lower limit based on linear assumption", *ibid.*, **8**(*1*) (1985) 25.

P.K. Marathe, Gouri Unnikrishnan and D. Krishnan, "Comparison of fast neutron RBE values based on the old and revised atom bomb dosimetry", *ibid.*, 21.

Kamala Gopakumar, Gouri Unnikrishnan and D. Krishnan, "Correlation between the radiolysis of TMP and a mixture of thymine and ribose - phosphate", Proc. Radiochem. Radiat. Chem. Symp. IIT, Kanpur, 1985; 286.

Kamala Gopakumar, Gouri Unnikrishnan and D. Krishnan, "Effect of scavengers on gamma radiolysis of thymine in O_2 & N_2", *ibid.*, 290.

N. Sankaranarayanan and B.S. Rao, "Induction of mitotic gene conversion in *Saccharomyces cerevisial* by cigarette smoke condensate", XI Annual Conference of Environmental Mutagen Society of India, Feb. 18-20, 1986; P-IV- 6 Abstract.

B.S. Rao and N. Sankaranarayanan, "Absence of synergistic interaction between cigarette smoke condensate and radiation for induction of genotoxic effect in yeast", *ibid.*, P-V-2, Abstract.

K.B. Anjaria and U. Madhvanath, "Effect of sodium selenite on methyl methane sulphonate induced gene conversion in yeast", *ibid.*, P-V-4 Abstract.

M.S.S. Moorthy and V.V. Deorukhakar, "Fate of exogenously supplied 1-Methyladenine in yeast auxotrophic to adenine", *ibid.*, S-7 Abstract.

K.B. Anjaria and U. Madhvanath, "Genotoxicity of selenite in diploid yeast", X Annual Conference of Environmental Mutagen Society of India, Bombay, Feb. 18-21, 1985; PA.III-6 Abstract.

M.S.S. Murthy and V.V. Deorukhakar, "Isolation and purification of yeast-nucleic acids using hydroxyapatite chromatography", *ibid.*, P IV-6, Abstract.

M.S.S. Murthy and V.V. Deorukhakar, "Failure of exogenous methylated adenine to induce cytotoxic and genotoxic effects in yeast auxotrophic to adenine", *J. Biosci.* **9** (1985) 223.

B.S. Rao, "Yeast in radiation biology", National Symposium on Yeast Biotechnology, Hissar, Dec. 12-14, 1985; Abstract No. 5.

M.S.S. Murthy, "Yeast as a tool in screening environmental chemicals for their genotoxic potentiality to man", *ibid.*, Abstract No. 6.

B.S. Rao, "Effect of hypoxia on the repair of damage induced by heat and radiation in cultured mammalian cells and its possible implications in radiotherapy", VII Congress of Association of Radiation Oncologists of India, Bangalore, Oct. 11-13, 1985; Abstract No. 7.

Nalini Raja, P.K. Arora, J.P.S. Chatha and K.G. Vohra, "Quenching O_2 ($^1\Delta g$) by aliphatic amines", *Int. J. Chem. Kinetics* **17** (1985) 1315.

U.C. Mishra, S. Gopalkrishnan and B.S. Negi, "Global movement of radio-active debris from Chinese atomospheric nuclear tests", *Mausam* **36** (1985) 1

N.B. Nair, C.D. Eapen and C. Rangarajan, "High airborne radioactivity levels due to radon in some non-uranium mines in India", *Radiation Protection Dosimetry* **11**(*3*) (1985) 193.

C. Rangarajan and C.D. Eapen, "Some observations on the concentrations of short-lived decay products of radon and thoron in the monsoon rains of Bombay, India", *Geophysical Research* **90**(*D5*) , (1985) 8155.

C. Rangarajan, C.D. Eapen and S. Gopalkrishnan, "Measured values of the dry deposition velocities of atmospheric aerosols carrying natural and fallout radionuclides using artificial collectors", *J. Water, Air and Soil Pollution* **27** (1986) 305.

P.V. Joshi, "Studies on the temporal and locational variations in the size distribution of atmospheric aerosols", Ph. D. thesis, University of Bombay, February 1986.

R.N. Khandekar, "Toxic heavy metal pollution from autoexhaust", Proc. of All India Seminar on Vehicular Emission, The Institution of Engineers India, Bombay, 1985; 300.

S.C. Ashawa, D.N. Kelkar and U.C. Mishra, "Wet deposition of cadmium, lead and copper at Deonar (Bombay) and its relationship with rainfall", *J. Water Air and Soil Pollution* **25** (1985) 63

M.C. Subba Ramu, T.S. Muraleedharan and K.G. Vohra, "A study of the attachment of radon daughter atoms to aerosol particles", *PAGEOPH* **122** (1985) 133.

A.N. Singh, M. Rathnakaran and K.G. Vohra, "An on-line tritium-in-water monitor", *Nuclear Instruments & Methods* **A 236** (1985) 159.

R.N. Sachdev and M. Sundaram, "Infrared instruments for measurement of carbon monoxide and hydrocarbons in automobile exhaust", Proc. All India Seminar on Vehicular Emission, Institute of Engineers, Bombay, 25-27 November, 1985; 1.1 - 1.8

J.P. Gupta, "Development and utilisation of infrared technique for measurement of carbon monoxide at some locations in Bombay atmosphere", Ph. D. Thesis, University of Bombay, 1985.

S. Sadasivan, "Application of neutron activation analysis in environmental sciences", IAEA-RCA Workshop on Neutron Activation Analysis, BARC, Feb. 4-22, 1985; *BARC/I-842* (1985) 320.

S. Sadasivan and T.N. Mahadevan, "Monitoring for pollutants in air and rainwater in current pollution researches in India", R.K. Trivedi and P.K. Goel (Eds.), Environmental Publications, Karad, 1985; 39.

U.C. Mishra, G.N. Shaikh, "Determination of trace elements in total particulate matter of cigarette smoke by instrumental neutron activation analysis", *J. Radio Analytical Chem.* **89**(*2*) (1985) 545.

U.C. Mishra, "Air pollutants and their monitoring, in *Current Pollution Researches in India* (Ed. R.K. Trivedi and P.K. Goel) Environmental Publications, Karad, Maharashtra, 1985.

T.N. Mahadevan, V. Meenakshy and U.C. Mishra, "Preliminary assessment of elemental composition of suspended particulate matter in Chembur-Trombay region, Bombay," *Ind. J. Env. Health* **27**(*1*) (1985) 9

U.C. Mishra and S. Sadasivan, "Report on R & D activities of Air Monitoring Section", *BARC-1257* (1985)

T.N. Mahadevan, V. Meenakshy and U.C. Mishra, "Trace elements in precipitation over an industrial area of Bombay", *Science of Total Environment* **48** (1985) 213.

U.C. Mishra, "Instruments and techniques for monitoring of gaseous pollutants and trace metals developed in Air Monitoring Section", Analytical and Environmental Instrumentation - Recent Studies and Applications, Workshop-cum-Symposium, JNU, New Delhi, Dec. 26-28, 1985.

U.C. Mishra, "Status of air monitoring instrument development in India", Envirotech-86 Conference on Air Pollution, Bombay, January 23, 1986.

U.C. Mishra, "Bioindicators as environmental pollution source indentifiers", Proc. Int. Symp. on Biological Monitoring of the State of the Environment (Bioindicators), New Delhi, October 11-13, 1984; 235.

U.C. Mishra and G.N. Shaikh, "Simultaneous multielement determination of chewing and snuff tobacco used in India by INAA", *J. Radio. Analy. Chem. Articles* **98**(*2*) (1986) 297

V.K. Shukla, "Radiological impact of production and use of phosphate fertilisers", Ph. D. thesis, Bombay University (1985).

T.V. Ramachandran, "Natural radionuclides in coal fuel cycle and non-radioactive underground mines", Ph. D. thesis, Bombay University (1985).

B.Y. Lalit and T.V. Ramachandran, "Natural radioactivity in India tea samples", *Radiation Environ. Biophysics* **24** (1985) 1

J.K. Srivastava and S.J. Supe, "Thermoluminescence of $CaSO_4$:Dy - A Semiempirical approach for qualitative analysis of non-linear TL effects", *Physica status solidi* (a) **92** (1985) 573

J.K. Srivastava and S.J. Supe, "On mechanism of radiation damage of thermoluminescence of $CaSO_4$:Dy", Proc. (Indian J. Physics) National Seminar on Solid State Physics, Calcutta, Feb. 14-17, 1985; 8 (Abstract).

J.K. Srivastava and S.J. Supe, "Relative effect of alpha and gamma radiations on thermally stimulated luminescence of $CaSO_4$:Dy", Proc. (Fusion Asia) National Seminar on Defects in Ionising Solids, Jamshedpur, Nov. 6-8 1985; DRI-4 (Abstract).

J.K. Srivastava and S.J. Supe, "Effect of LET on thermoluminescence response characteristics of $CaSO_4$:Dy", National Symposium on Radiation Physics, Kalpakkam, March 3-6, 1985; C-90 (Abstract).

P. Sundaresan, K.B. Sainis, G.P. Phondke and K. Sundaram, "Suppression of skin allograft rejection by post transplantation administration of specific antilymphocyte serum", *Immunology letters* (in press).

S.D. Bharambe, K.B. Sainis, K. Sundaram and G.P. Phondke, "Effect of whole body gamma irradiation on delayed hypersensitivity to dinitrofluorobenzene in CBA mice", *Indian J. of Experimental Biology* **23** (April 1985) 175-179.

S.D. Bharambe, K.B. Sainis, G.P. Phondke and K. Sundaram, "Electrokinetic status of sub-populations of lymph node cells in contact sensitized CBA mice", *Folia Biologica* (in press).

P.K. Ray, M. Seshadri and T.B. Poduval, "Immunity and its role in conventional cancer therapy", *Advances in Immunity and Cancer Therapy* (Ed. P.K. Ray Springer Verlag, New York, 1985; Vol. 1: 29 - 98.

M.S. Rajadhyaksha, D.S. Joshi, G.P. Phondke, K. Sundaram and R. Mitra, "Latic dehydrogenase isozyme distributions in lymphocytes from normal and leukemic mice", *Cancer Biochemistry Biophysics* (in press)

G. Pande, D.S. Joshi, K. Sundaram and M.R. Das, "Identification and characterisation of two subpopulations of cells with different lethalities in a rat ascitic hepatoma", *Cancer Research* (in press).

E. Selvan, S.P. Nene, D.S. Joshi, K. Sundaram and S.G.A. Rao, "Heparin induced nuclear decondensation in murine spermatogenic cells", *Advances in Contract Del. Systems* (in press).

V. Sen, D.F. Nerkar, D.S. Joshi and N.F. Lewis, "Modulation of macrophage activity by microorganisms", *Ind. Journal of Exp. Biol.* (in press).

S.D. Soman and K.C. Pillai, "Safety and environmental aspects of nuclear fuel cycle operation", Int. symp. on environment and industrial safety, New Delhi, 2-5 Feb. 1985.

V.N. Shastry, A.C. Paul and K.C. Pillai, "Environmental safety evaluation of mixed cake storage in underground trenches", XIII IARP Conf. Proceedings, Calcutta, 1986.

R.K. Hukkoo, V.N. Bapat and V.V. Shirvaikar, "Fortran-graphic display of long term doses from routine atmospheric releases of radioactivity", *B.A.R.C/I-854* (1985).

R.N. Nair, T.M. Krishnamoorthy and T.P. Sarma, "Tide induced mathematical model for coastal radioactive discharges and its application", *Indian J. Marine Sciences* **14** (March 1985) 9-14.

R.K. Hukkoo, V.N. Bapat and V.V. Shirvaikar, "Atmospheric dispersion evaluation under elevated inversion lid", *Atmospheric Environment* **19**(*3*) (1985) 529-531

R.S. D'Souza, V.N. Sastry, G.R. Doshi, T.M. Krishnamoorthy and T.P. Sarma, "Disposal of radioactivity on to Arabian Seabed Radiological impact calculations", *Bulletin of Radiation Protection* **1** (*1&2*) (1986) 143-146.

R.N. Nair, T.M. Krishnamoorthy and T.P. Sarma, "A Nomogram to Compute Concentration of Radionuclides in Canals", *ibid.*, 147-150

J. Swarup and L.H. Peshori, "Transmitted Photon Spectra of Low-energy Gamma Rays through Water", *Int. J. Appl. Radiat. Isot.* **36** (*7*), 531-535.

T.P. Sarma and T.M. Krishnamoorthy, "Parent-daughter Equilibria in Ocean Arising out of Disposal of Solid Radioactive Wastes on the Sea Bed", *Indian J. Marine Sciences* **15** (1986) 1-7

V.K. Jain, "Nuclear Energy and Radiological Protection", *Science Reporter* (September, 1985) 292-297

V.K. Jain and M. Shah Jahan, "Analytical Picture of the Effect of Temperature Treatment on UV and Gamma Ray Sensivity of CaF_2-based TLD", *J. Phys. D : Appl. Phys.* **18** (1985) L15-L17.

R.G. Purohit, V.K. Jain and T. Subbaratnam, "A Unique Method of Determining ^3H Intakes as a Fraction of the Annual Limit of Intake", *Health Physics* **49**(*6*) (1985) 1261-1265

V.K. Jain, "Risk Evaluation and Protection Against Ionising Radiation", *Pramana* **24** (*1&2*) (1985) 279-292

V.K. Jain and M. Shah Jahan, "Changes in the Spectrum of Thermally Stimulated Emission from CaF_2:Mn at Low Temperatures", *Phys. Stat. Sol. (b)* **131**, 1985 K161.

V.K. Jain and M.S. Jahan, "Low Temperature Thermoluminescent Characteristics of CaF_2:Mn", *Phys. Stat. Sol. (a)***92** (1985) 237

V.K. Jain and M.S. Jahan, "Influence of Mn Concentration on the Thermoluminescence of CaF_2 in the Temperature Range 90-300K", SESAPS Meeting, Athens, Georgia, Dec. 1985, and *Bull. Am. Phys. Soc.* **30** (*10*) (1985) 1783

V.K. Jain, M.S. Jahan and D.W. Cooke, "Low Temperature Thermoluminescence

of CaF_2:Mn", Annual Meeting of the American Physical Society, Baltimore, MD, USA, March 25-29, 1985.

S.B. Dabhadkar, Pushparaja, D.R. Raipurkar and S.K. Mehta, "Radiation Safety Evaluation Studies on Sludge Transport Casks", *Bulletin of Radiation Protection* **8** (Jan-Mar 1985).

S.B. Dabhadkar, Pushparaja and T. Subbaratnam, "Shop Testing for Shielding Integrity of Lead Assemblies for Nuclear Installations : An Overview of Actual Experience of Over a Decade", Symp. Construction and Commissioning of Nuclear Power Plants and Their Associated Systems , Bombay, Feb. 25-27, 1985

O.H. Mahajan, T.R. Joshi, R.V. Joshi and S.P. Kathuria, "Kinetics and Trapping Parameters for 220°C TL Dosimetry Peak in NaCl:Ba(T)", *Nucl. Tracks.* **10** (*1&2*), (1985) 89-92

S.C. Sabharwal, S.P. Kathuria and B. Ghosh, "Thermoluminescence in Gamma-Irradiated NaI (TL) Crystal", *ibid.,* 107-110

S.V. Moharil and S.P. Kathuria, "Evolution of TL and PTTL Glow Curves in LiF TLD-100", *J. Phys. D. Appl. Phys.*. **18** (1985) 691-701

S.P. Kathuria, S.V. Moharil and C.M. Sunta, "Some Interesting Observations on the Optical Absorption Spectra, Thermoluminescence Spectra and Order of Kinetics of Lithium Fluoride", *ibid.,* 61-69

B. Patel, Vasanti S. Bangera, Shakunt Patel and M.C. Balani, "Heavy Metals in the Bombay Harbour Area", *Marine Pollution Bulletin* **16** (*1*), (1985) 22-28

S. Patel and B. Patel, "Effect of Environmental Parameters on Pysosomal Marker Enzymes in the Tropical Blood Clam Anadara Granosa", *Marine Biology* **85** (1985) 245-252

B. Patel, M.C. Balani and S. Patel, "Sponge Sentinel of Heavy Metals", *The Science of the Total Environment* **41** (1985) 143-152

B. Patel, S. Patel and M.C. Balani, "Can Sponge Fractionate Isotopes", *Proc. R. Soc. Lond. B.* **224** (1985) 23-41

A. Seidel, E. Kriger, M. Wiener, G. Hotz, M. Balani and W.G. Thies, "Association of ^{239}Pu with Lysosomes in Rat Syrian Hamster and Chinese Hamster Liver as studied by Carrier Free Electrophoresis and Electron Microscopic Autoradiography with ^{241}Pu", *Radiation Research* **104** (1985) 191-199

S.K. Mehta, I.K. Oomen, S. Sengupta and S.D. Sorrian, "Gamma Dosimetry Using Lyoluminescence of TRIS (Hydroxymethyl) Aminomethane", *Nuclear Instruments and Method* **231** (1983) 393-396

I.K.Oomen, S. Sengupta, M.V. Krishnamurthy and S.K. Mehta, "ESR and Lyoluminescence Measurements TRIS (Hydroxymethyl) Amino-methane", *Nuclear Instruments and Method in Physics Research A* **240** (1985), 406-409

A.K. Babar, V.V.S. Sanyasirao and T. Subbaratnam, "Bayesian Techniques in Validating a Data Base", Indo-German Workshop on Transients, BARC, January,1985

D. Bhattacharya, S.S. Bajaj, A.K. Babar and V.V.S. Rao, "Reliability Evaluation of Nuclear Power Plant Safety Systems", National Conference on Quality and Reliability,Indian Institute of Technology, Bombay (1985).

D.J. Mehta, "Physical Studies and Clinical Investigations Using Linear Digital Whole Body Radioactivity Profile Scanner", Ph. D. Thesis, University of Bombay (1985).

D.J. Mehta, "Multi-slits Focussing Type Collimator for Linear Whole Body Radioactivity Profile Scanner", 17th Annual Conference of Society of Nuclear Medicine, Bangalore, January 1-5, 1986

R.C. sharma, T. Surendran, T.K. Haridasan, G. Krishnamachari and S. Somasundaram, "Measurements on IAEA Realistic Phantom: Preliminary Evaluation", Report submitted to IAEA, March,1985.

R.C. Sharma, T.K. Haridasan, T. Surendran and S. Somasundaram, "Measurements on IAEA Realistic Phantom for Assessment of ^{241}Am Lung and Lymphnode Burdens and their Efficacy to Study the Clearance of $^{241}AmO_2$ from Human Lungs", Biennial BARC Report, 1984-85 (in press)

D.K. Kapur, R. Dhandayutham, M. David and C.M. Sunta, "Intercomparison of Whole Body Counters Located in Different Units of DAE," XII Annual Conf., IARP, Bombay, March 18-21, 1985.

M. David and C.M. Sunta, "Quartz Dosimeter for Archaeological Dating", *Nuclear Tracks* (1985).

M. David, "TL of Quartz - Part XII, Effect of Neutron Irradiation", *Ind. J. Pure & Appl. Phys.* **23** (1985) 267

M. David, "Thermoluminescence and its Application", *Science Reporter* **22 (6)** (1985) 356

M. David, "Tracing of Monoxite and its Origin by Radiation Dosimetry", *Ind. J. Earth Science* **12**(*3*), (1985) 179-186

K.S.V. Nambi, M. David, A.S. Basu and C.M. Sunta, "Environmental Radioactivity and Thermoluminescence: A Review", *J. Environ. Radioactivity* **2** (1985) 59-75.

K.S.V. Nambi, "Scope of Electron Spin Resonance in Thermally Stimulated Luminescence Studies and in Chronological Applications", *Nuclear Tracks and Rad. Meas.* **10** (1985) 113-132.

A.V. Sankaran, K.S.V. Nambi and C.M. Sunta, "Thermoluminescence of Laterites: Application in Dating", *ibid.,* 177-184.

K.S.V. Nambi, S.M.D. Rao and M.P. Chougaonkar, "Luminescence and Field Emission associated with Heating and Cooling of Pyro-electric Materials : Pyroelectroluminescence," *ibid.,* 243-247

M. David and K.S.V. Nambi, "Alpha Irradiation induced Changes in Thermoluminescence Saturation and Fading Characteristics of Commonly used TLD Phosphors", *ibid.,* 274-275.

A.S. Basu and K.S.V. Nambi, "Thermoluminescence Evaluation of Natural Gamma Background Radioation Levels in Kalpakkam Region Prior to Commissioning to Nuclear Power Station", *ibid.,* 284-285.

K.S.V. Nambi, S.M.D. Rao and M.P. Chougaonkar, "Thermoluminescence Dating of Synthetic CaF_2:U Crystals", *Nuclear Track* **19** (1985) 673-681.

K.S.V. Nambi, "Comments on TL Age under Estimate of Stalaganitic Calcite", *Ancient TL* **3** (1985) 528.

K.S.V. Nambi, "TL and ESR Terminology : k Factors", *ibid.,* 22.

M.N. Bapat, S. Sivaraman and K.S.V. Nambi, "TL of MgO: Li (Ce, Eu)", *Indian J. Pure & Applied Phy.* (1985).

Kamala Rudran, "Invivo Organic Binding of Radionuclides and Its Role in Internal Radiation Exposure", Ph. D. Thesis, University of Bombay (1985).

K.B.S. Murthy, C.M. Sunta, D.T. Khatri and G.E. Prasad, "Energy Measurement of Exo-electrons", *J. Phys. E. Sci Instrum.* **18** (1985) 350-353.

K. Unnikrishnan and M.A. Prasad, "Occupancy Time for Correlated Random Walks with Partially Absorbing Boundaries", *Acta Physica Austriaca* **65** (1985) 253.

M.A. Prasad and K. Unnikrishnan, "Asymptotically Exact Solution of the One

Dimensional Trapping Problem with Correlation", *Phys. Rev. A* **31** (1985) 523.

C.M. Sunta, "Thermoluminescence of Calcium Based Phosphors", *Nuclear Tracks* **10** (1985) 47-53.

S.S. Ranade and V.K. Panday, "Major Metals in Human Cancer: Calcium, Magnesium, Sodium and Potassium", *Science of Tot. Env.* **41** (1985) 79.

B. Singh, V.R. Shah, N.U. Gulvady and M. Parameswaran, "Mercury Levels in Blood and Urine of Healthy Young Adults", *Ind. J. Occ. Health* **28** (1985) 43.

V.K. Panday, M. Parameswaran and S.D. Soman, "The Distribution of Mercury in the Indian Population", *Science of the Total Environment* **48** (1986) 223-230.

D.D. Jaiswal, H.S. Dang and C.M. Sunta, "Distribution of Thorium in Human Tissue" *J. Radioanalytical and Nuclear Chemistry*, Article 88/2 (1985) 225-229.

H.S. Dang, D.D. Jaiswal and C.M. Sunta, "Daily Intake of Thorium by an Indian Urban Population", *Science of the Total Environment* (in press).

R.S. Iyer and I.S. Bhat, "Technitium-99 in the Tarapur Marine Environment", 12th Annual Conference, IARP, Bombay.

R.C. Verma and I.S. Bhat, "Measurement of Beryllium-7 in the Tarapur Environment", *ibid.*,

T.A. Sebastian, R.P. Gurg and I.S. Bhat, "Natural Detoxification of Hydrogen Sulphide Laden Aquatic Effluents in the Environment". Progress Report for 1985 of Environmental Survey Lab., TAPS.

S. Sengupta, S.D. Pradhan, I.K. Oommen and S.K. Mehta, "Radiation Safety in NDT LINAC Facility", *ICAIRD-1984* Bombay.

M.P. Mogal, R. Venkataramani, G.R. Nair and S.K. Mehta, "Radiation Safety Experience during Installation of 80 kCi 60Co Source in Panbit", IARP Conference, Bombay, March, 1985.

A.M. Bhagwat, V.B. Joshi and S.D. Soman, "Evaluation of Neutron Dosimetric Properties of C.R. 39 (PM-555-100)", IV National Seminar-cum-Workshop on SSNTD, Dehra Dun, 4-6 Nov., 1985.

L.M. Kukreja, V.B. Joshi, A.M. Bhagwat, H.K. Chatterjee and D.D. Bhawalkar, "Modification in Track Revelation Properties of CR-39 due to Laser Treatment", *ibid.*

N. Swaminathan, A.M. Bhagwat and S.D. Soman, "Evaluation of Neutron Dosimetric Properties of CR-39 (PM-555-100) by Electrochemical Etching Technique", VI National Symposium on Radiation Physics, Kalpakkam, 3-6 March, 1986.

"Global Radiological Impact of Longlived Radionuclides from Nuclear Fuel Cycle", IAEA Inter-regional Training Course on Radiation Protection, BARC, Bombay, March, 1985.

"Separation and Trapping Studies on Iodine-129 from Effluent Water" IAEA Inter-regional Training Course on Radiation Protection, BARC, Bombay, May, 1985.

S.M. Shah and V.R. Deo, "Dielectric Plastic Films as High Level Gamma Dosimeters", *Radiation Physics & Chemistry* (1986, in press).

A.M. Bhagwat, S.K. Mehta, D.P. Pimputkar and N. Swaminathan, "Assessment of Internal Radiation Hazard from Alpha Air-activity in the Working Environment", IARP Conference, Bombay, 1985.

R.K. Hukkoo, V.N. Bapat and V.V. Shirvaikar, "A Fortran Graphic Package for Synoptic Display of Radiologic Impact of Atmospheric Releases of Short Duration", *BARC/I-847* (1985).

A.R. Lakshmanan, T. Krishna Rao and S. Viswanathan, "Nitrate and Fluoride Levels in Drinking Waters in the Twin Cities of Hyderabad and Secunderabad", *Ind. J. Environ. Hlth.* **28** (*1*) (1986) 39-47.

A.R. Lakshmanan, T. Krishna Rao and S. Viswanathan, "Occurrence of Uranium in Ground Water in the Twin Cities of Hyderabad and Secunderabad", *ibid.*, **27** (*2*) (1986), 165-168

T.N. Krishnamurthi, S. Janardhanan, V.K. Sundaram and S. Somasundaram, "Evaluation of Radiological and Nuclear Safety in Mixed Carbide Fuel Production Flowsheet for FBTR", *Bulletin of Radiation Protection* **8** (*1*) (Jan-Mar, 1985)

P.P. Joshi, V.B. Menon and P. Kotrappa, "Heat Generation Rate in High Active Waste Storage Tank", *ibid.*

S.K. Dua, N. Gopalan, P. Kotrappa and P.P. Chakraborty, "Double Filter Method for Measurement of Concentration of Radioactive Krypton and Xenon Gases", *ibid.*

A.M. Curtay, P. Kotrappa and P.C. Gupta, "An Improved Electret Charge- Reader", *ibid.*

S. Venkataraman, "Uranium and Radium-226 in Wells around the Uranium Complex at Jaduguda", *ibid.*

K.P. Eappen, P.N. Markose and K.C. Pillai, "Fractionation of Radionuclides in Acid-Leach Process of Uranium Ore", *ibid.*

P. Kotrappa, D.P. Bhanti, S.V. Malvankar, B. Raghunath and A.M. Curtay, "Aerosol Release Factor for Pu as a Consequence of Ion Exchange Resin Fire in Process Cell of a Fuel Reprocessing Plant", *ibid.*

N.N. Dey, S.J. Raut, K.P. Satheedevi, S. Usha and K.C. Pillai, Evaluation of Radiation Exposure to Population from Release of Treated Effluents to Bombay Harbour Bay from the Nuclear Centre at Trombay", *ibid.*

G.K. Srivastava, A.H. Khan and M. Raghavayya, "Utility of Low-Level Radon Detection System", *Bulletin of Radiation Protection* **8** (*2*), (April-June 1985).

K.N. Kirthi, S.D. Pradhan and S. Somasundaram, "Design Safety Considerations for Pelletron Accelerator", *Bulletin of Radiation Protection* **9** (*1 & 2*) (Jan-June, 1986).

R. Mukherji, S.K. Basu, M. Bar, B.K. Khasnabis, "Measurement of Induced Activity at VECC", *ibid.*

G. Muthukrishnan, "Monitoring of cyclotron produced radiations", *ibid:*

K.N. Kirthi, S. Sengupta, T.S. Iyengar, S. Somasundaram, P.N. Moorthy and R.M. Iyer, "Sefety Considerations during the Operation of a 7 Mev Electron Linear Accelerator", *ibid.*

K.V. Kamath, J.L. Kapoor, S.K. Mehta and S.R.K. Iyer, "Safety Experience in Transportation of Radioactive Materials", *ibid.*

R.K. Gopalakrishnan, S.G. Sahasrabudhe and M.R. Iyer, "An Activation Method for the Assay of U Enrichment", *ibid.*

A.H. Khan and M. Raghavayya, "Radiological Characteristics of Uranium Mine Atmosphere", *ibid.*

G.K. Srivastava, "Analysis of Radium Body Burden Data of Uranium Mine Workers", *ibid.*

S. Venkatraman and A.H. Khan, "Radium-226 Content of Effluents from a Copper Mine and Concentrator", *ibid.*

M. Raghavayya, A.H. Khan and G. Jha, "Dose Esitimation for Jaduguda Mine Workers", *ibid.*

A.C. Paul and P.M.B. Pillai, "Radiation Exposure in the Mining and Mineral Separation of Coastal Sands", *ibid.*

K.P. Eapen, P.M. Markose and K.C. Pillai, "Amine Extraction for Uranium Estimation", *ibid.*

S.P. Kathuria, S. Somasundaram and T. Subbaratnam, "Training Programmes in Radiation Protection and Certification of Health Physics Personnel in Nuclear Fuel Cycle Facilities", *ibid.*

M.C. Abani, M.M.K. Suri, S. Somasundaram and S.D. Soman, "Technical Requirements of a Computer Aided Health Physics Surveillance Programme", *ibid.*

S. Venkatesan, "Study of Response of Process Radiation Monitor and its Application to Alarm and Trip Points", *ibid.*

K.S.V. Nambi and S.D. Soman, "Inverse Correlation between Cancer Risk and Natural Background Radiation in Five Indian Cities", *ibid.*

D.D. Jaiswal, H.S. Dang, V.R. Pullat, K.B.S. Murthy, P.P.V.J. Nambiar and C.M. Sunta, "Urinary Thorium Levels in Normal and a Group of Occupationally Exposed Persons", *ibid.*

K. Unnikrishnan, K.B.S. Murthy, Shiv Datta and C.M. Sunta, "Estimation of Intake of Plutonium and Thorium from the Measurement of Lung Burdens and Elimination Rate. Implications for Internal Monitoring Periodicity", *ibid.*

B.D. Bhasin, G.N. Kalyane and S.P. Kathuria, "TL Characteristics of LiF (Polish) Pellets for Reassessment of Absorbed Dose by Proto-transferred Thermoluminescence", *ibid.*

I.S. Bhat, A.G. Hegde, P.C. Verma and R.S. Iyer, "Behaviour of Ni-63 in the Marine Environment", *ibid.*

K.K. Narayanan, B.M.L. Sah and T. Subbaratnam, "Application of the ICRP Paris Statement (1985) for Revision of Derived Limits for Environmental Discharges from Indian NPPS", *ibid.*

V.N. Sastry, A.C. Paul and K.C. Pillai, "Environmental Safety Evaluation of Mixed Cake Storage in Underground Trenches", *ibid.*

M.V.M. Desai, V.V. Kulkarni, N.N. Dey and K.C. Pillai, "Distribution of Cesium-137 in Sand-Silt and Clay Fractions of Marine Sediments", *ibid.*

9. ELECTRONICS & INSTRUMENTATION

9·1 Electronics

A multi-bus compatible, Intel 8086 based computer with 512 K bytes memory was developed and coupled to Norsk Data computer ND-560 for development of Intel-8086 based programs using cross assembler on ND. A file transfer utility was developed for 8086 to download object code from ND to 8086 computer and transfer back the debugged object file. A 16–bit Micro Computer System with 2 Floppy disk drives and with CP/M 86 operating system was developed for software development. Control, Process and Health instrumentation required for DHRUVA were commissioned. This is the first time that Campbell based control channels are used in closed loop to control the power of a reactor. Instruments were designed to withstand environmental as well as seismic tests. Notable feature of these instruments is the use of microprocessors to reduce hardware but to increase the processing power of instruments.

A gamma ray level detector system was installed at Uranium Metal Plant for monitoring the progress of reduction of uranium fluoride to uranium metal using magnesium. A shut down area monitor was successfully tested for seismic conditions and was approved by Nuclear Power Board for production.

Development work on Fuel Rod Scanning System, Gamma Camera, and Ultrasonic Imaging Systems is nearing completion. Camac and fast bus instrumentation and multiprocessor based Data Acquisition System are under development.

Expertise developed in microprocessor based instrumentation techniques is being applied to the development of impedance cardiograph, real time ultrasonic image processing system and other medical instruments.

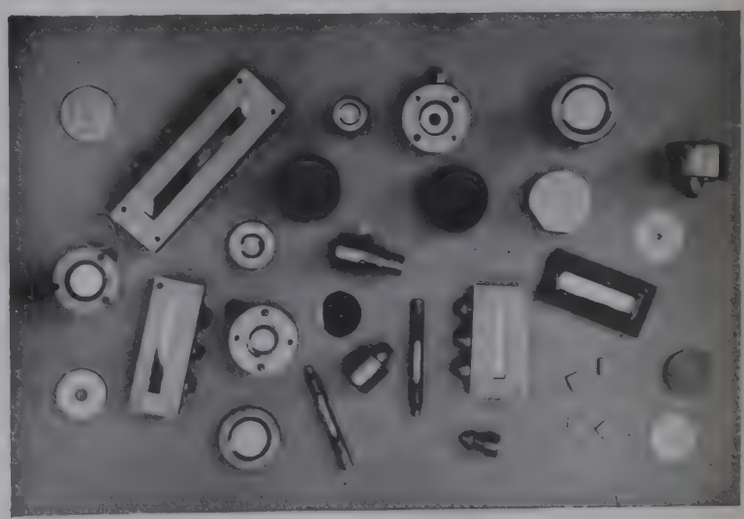
9·2 Instrumentation

Work related to the development and production of vacuum devices, various mass spectrometers, surface analytical instruments, electronic instruments, crystals, detectors and devices for the nuclear programme was continued. Besides, expertise in the field of vacuum and cryogenics was made available to the Indian Space and Defence organizations.

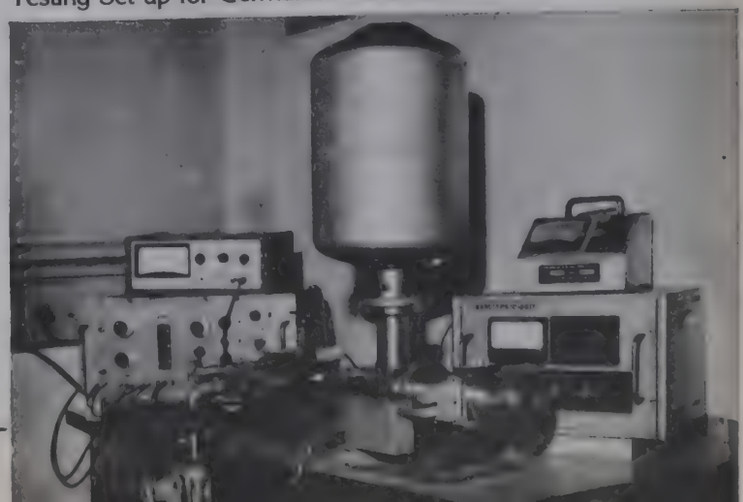
An apparatus for monitoring hydrogen concentration in sodium was successfully developed for FBTR, Kalpakkam. An ultra high vacuum outgassing system was set up for assessing the vacuum capability of materials for use in accelerators and in fusion research.

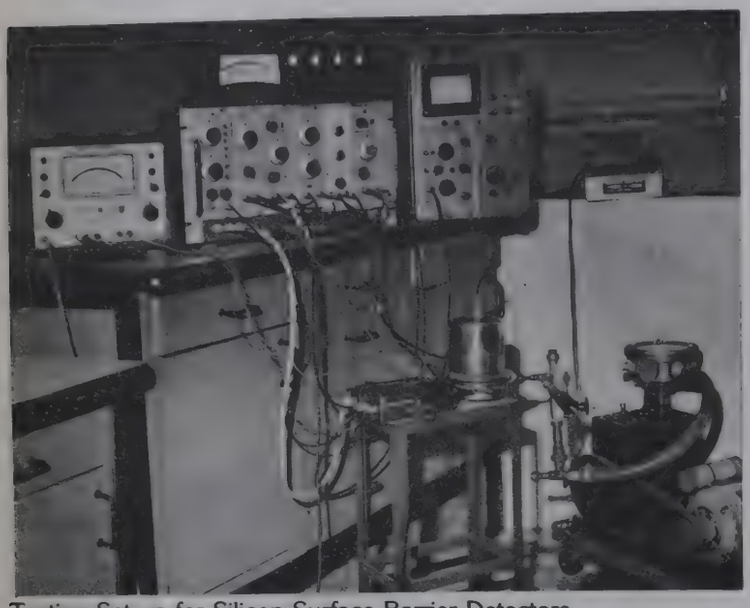
A large ultra high vacuum chamber of 450 litres volume at 1×10^{-9} Torr, and a large high vacuum system of 20 m^3 volume at 10^{-2} Torr were designed for a gravitation experiment being conducted by TIFR. A thermovac chamber 3m diameter and 3·5 long was designed for Space Application Centre, Ahmedabad for testing optical payloads (cameras, etc) of the Indian Remote Sensing Satellite (IRS) and the Communication Satellite (INSAT II). A high altitude chamber, 4m diameter and 10m long, was designed for DRDL, Hyderabad for testing defence payloads.

Semiconductor Nuclear Radiation Detectors



Testing Set up for Germanium Detectors





Testing Set up for Silicon Surface Barrier Detectors

Automatic microprocessor based sample inlet systems are being installed with mass spectrometers for continuous on-line, isotopic ratio measurements on gaseous samples of nuclear materials. A quadrupole mass spectrometer was developed for reactor cover gas analysis. A microprocessor based signal averager for biomedical applications and a programmable stepper motor speed controller and sequencer for crystal puller were developed.

For infrared detectors, special crystals of lead germanate, triglycine sulphate and mercury cadmium telluride, and for laser application, lithium niobate and potassium dihydrogen phosphate crystals were grown and characterized. A special crystal puller for the growth of the laser crystal YAG : Nd is being installed. Production of optical windows and semiconductor detectors was continued.

A special Geiger Muller tube was developed for ONGC for a fluid density measurement instrument which is used in oil well logging. Regular production of high power xenon flash lamps for lasers, glass to metal seals for canned motors. level sensors for heavy water projects and hollow cathode lamps for atomic absorption spectrophotometry was continued.

9·3 Computer Based Instrumentation

Laboratory Automation

Work has been undertaken for the development of multichannel analyser logic which will be of use in both single and multiparameter experiments. The entire hardware logic for a 4K time analyser has been completed. Using two low cost microcomputers, a Data Acquisition System for Laser Raman Spectrometry has been designed for automatic control of a Laser Raman spectrometer. A printer/plotter peripheral has been integrated with a Mass Spectrometer. Using 8085 microprocessor, a Digital Averager with V/F converter has been developed. There is considerable demand for this unit. A microprocessor based data acquisition system for Mossbauer Spectrometer has been developed. A Polarised Neutron Spectrometer Control System was developed and implemented on the spectrometer that was supplied to the Korea Advanced Energy Research Institute, Korea (KAERI). The system is reported to be functioning very satisfactorily.

Communication Systems

Based on the feedback received from the technology transfer effort, various new features have been added to the microprocessor based PABX. The video digitiser developed earlier has been interfaced with the Norsk Data computers as an image input device. It is now possible to transfer entire image from the digitiser to ND or from ND to the digitiser, and to transfer a part of an image from ND to the digitiser. Software has been developed to create a picture bank and link it with the Personnel Data Base so as to display photograph of a person on the graphic display terminal by keying in the name or computer code number.

9·4 Control Engineering

The control system of the 2·3 metre telescope of the Indian Institute of Astrophysics at Kavalur was commissioned. The control system is capable of acquiring and tracking accurately any selected star, planet or any other astronomical object in the sky. Since November 1985 this telescope has been successfully used to track and photograph Halley's Comet.

About one hundred canned motors of 3·75 KW capacity were fabricated and despatched to Heavy Water Projects. Two of these motors are installed in Tuticorin Heavy Water Plant. These motors have stainless steel canned stators and rotors with special glass to metal seals for power supply connections. These have been tested continuously for one and a half years in corrosive potassium amide and liquid ammonia at a high pressure of 650 bars.

A microprocessor based image analysis system for quantitative metallography was fabricated and commissioned at the Radiometallurgical Laboratories at IGCAR. In this system a solid state charge coupled device camera views the sample or micro-graph and the information is digitized and stored in memory. The analysis is carried out for computation of geometrical parameters and the formatted results are printed out.

A five hundred counts per revolution optical shaft encoder was developed for sensing precision robot arm position movements.

A microprocessor based control system for the positioning and display of rotory and linear motions of Electron Beam Welding Machine was designed and fabricated. The system employs AC servomotors for the drive system and incremental encoders for accurate positioning. The controller provides automatic welding sequence for the pulse track welding of tubular parts.

Electrical and mechanical design of automatic resistance welding machine for welding end caps for special materials was completed. Mechanical fixtures were fabricated and the testing of electrical circuits is in progress.

The installation and commissioning of a two phase chopper of 1500 kW rating at 1500 volts for the motor coach of an Electrical Multiple Unit was completed and field trials were carried out. The regenerative braking system is found to save energy to the tune of 20 percent compared to that of conventional rheostatic controlled coaches. These successful prototype trials could lead to the conversion of all motor coaches in the suburban section of Western and Central Railways resulting in the saving of 100 million units of electrical energy every year.

The installation of the giant 300 tonne moving magnet at the pilot plant in Trichy was completed. The magnet power supply having a rating of 3000 Amps, 1·6 MVA was commissioned and the magnet was energized.

Castor oil filled, polyestor dielectric film capacitors of 50 micro farad, 7 kV rating were developed and tested. The design of 100 micro-farad, 5 kV rating capacitor has been completed. These capacitors find applications in Laser and Fusion programmes of DAE.

An electronic telecryptor which permits safe transmission of special coded messages through telex lines was developed and commissioned. A two key electronic combination lock was developed, which can be opened by operators after entering proper codes in a predetermined sequence in a specified time interval. An integrated security alarm reporting system was developed and commissioned around Radiological Laboratories at Trombay in October, 1985. The system uses signals from micro-wave and infra-red intrusion detectors placed at strategic locations in Radiological Laboratories.

An ingenious scheme for the allotment of short and unique identifying code to every person in the country was prepared after reviewing the numbering systems of many countries. The plan is based on the concept of six digit phonetic code numbers of radix 128 which can be written in any Indian script.

9·5 Computer Research

Making use of the INIS output magnetic tapes obtained from IAEA, a CODASYL based DBMS called SIBAS available on ND system has been used for developing the information retrieval system. Using this system it is possible for a user to perform a search on any of the several access points such as, author, title, subject, category and descriptors. Plot 10 IGL V24 supporting colour graphics has been implemented, for study of engineering structures, 3D distributions, image analysis etc. A Window Annunciator Logger (WAL) for RAPP-II has been delivered and has been functioning very satisfactorily. Status changes in 640 inputs are indicated which are in parallel with the existing window annunciator system. Hard copy print out generated by WAL are very useful for operational diagnostics. Similar

units are required for RAPP-I and MAPP.

A system has been designed and fabricated for quality surveillance programme for the purpose of non-destructive testing of cylindrical tubes using eddy current measurements. The material defects along with the relative positions can be pin-pointed with the help of this system,

Software Development

Design and development of a software package on ND computer has been taken up for Tata Memorial Centre in order to provide facilities for online storage and retrieval of medical information for patient care, medical research, statistical analysis, etc. It will also include facility for scheduling and management of various hospital activities. A patient Monitoring System for critical care unit with menu driven programmes, data base package for storing and retrieval of patient information and for display of various paramaters in graphic form has also been developed.

Personal computers have been used for computer animation. A package has been developed for dynamic presentation of slides explaining topics relating to the various technical activites of BARC.

A two dimensional drafting package useful in engineering applications, and colour graphics have been implemented. A link has beeen provided between ND computer and VG 3400 3D graphics system. This permits display of graphics image on high resolution VG 3400 system.

9·6 MHD Generation

The MHD Research Project sponsored by the Department of Non-Conventional Energy Sources is being jointly executed by Bhabha Atomic Research Centre, Bombay and Bharat Heavy Electricals Limited, Tiruchirapalli. This includes the creation of a suitable base for research and development work in the field of MHD power generation and setting up of an experimental plant at Tiruchirapalli at a thermal power level of 5 MW. BARC has developed most of the key components of the facility including the MHD generator, 300 tonne electro-magnet, special plasma diagnostic equipment, high temperature ceramic materials and control and instrumentation system for the experimental plant. The plasma generation experiments were carried out during March 1985, yielding MHD grade plasmas at a temperature of 2700 K and an electrical conductivity of 5 mho/m. Following the plasma generation run, the first successful power run of the plant with cold oxidizer using 60% oxygen enrichment was accomplished during August 1985. The power mode operation lasted for about 2 hours. The successful testing of the facility demonstrated that the Indian MHD facility operated as an integrated unit and substantiated the physical concepts, computer codes, design features and special processing techniques. It also established the suitability of the materials used in the development of MHD plants.

9·7 Pulse Power & Particle Beams Technology

Pulse power techniques and particle beams have potential applications in materials research, fusion research, defence and industry. The 1 kJ pulse power system for relativistic electron beams (REB-1000) based on deionised water, assembled during the last year, was satisfactorily tested at 150 kV and 15 kA. Further tests to operate at full ratings are in progress. The spark gaps and trigger circuits of the 100 kJ capacitor bank are being modified to improve its performance. Fabrication of a 5 kJ, 1MV pulse power system is in progress. To facilitate measurement of low level diagnostic signals in the presence of high electromagnetic impulse produced by the pulse power systems, an electromagnetic shielded enclosure with overall dimensions of 6 m × 3·7 m × 2·2 m was produced and installed. The REB-200 system built earlier was modified with an all-metal interaction chamber and a 40 cm diameter magnet coil for mirror magnetic field. Diagnostic instruments were incorporated for measuring plasma temperature, plasma density and beam energy loss. A 35 GHz microwave interferometer for electron density measurements on this system was assembled and preliminary tests of the interferometer are in progress using a plasma gun.

REB transport calculations were carried out for a 1 MeV, 15 kA, 30 ns beam in giving optimised maximum tranport of 85% at 0·1 Torr in argon and 0·5 Torr in

hydrogen. A practical application of magneto-implosive effects of high pulsed magnetic fields is repositioning of garter springs located in the annular space between the pressure tube and the calendria tube of PHWRs. With the 25 kJ capacitor bank, a displacement of 25 mm was obtained per discharge shot in a simulated set-up. Based on these studies a scaled-up system is being designed.

Electron beam is a highly energy efficient heat source for metallurgical applications such as melting, welding and evaporation, and is almost indispensible when working with highly reactive and high temperature materials required in nuclear and aerospace industry. Two of electron beam systems rated at 150 kV, 6 kW beam power are being built for Electron Beam Welding Machines for special applications. An electron beam melting furnace with 80 kW power is being built for melting of hafnium and niobium. An electron beam evaporation system of 20 kW power and mean applications is being designed. The electron beam welding machine developed and built earlier was used to do some of the special jobs within DAE and for the Departments of Space and Defence.

Publications

S.K. Iyengar, G. Venugopala Rao, K.C. Mittal and V.K. Rohatgi, "Diagnostics for intense pulsed particle beams", Proc. Workshop on Plasma Diagnostics, Centre for Advanced Technology, Indore, 1986 (Review Talk)

S. Challappa, M.G. Srinivasan and P.P. Chandrachoodan, "Ultrasonic examination of electron beam welded tube-to-tube-sheet dissimilar metal joints-A case study".

G.S.K. Murthy, "Electron beam welding of tube-to-tube-sheet type of joints in nuclear reactor storage and shielding blocks".

S.C. Sabbarwal and B. Ghosh, "Electrical Conductivity of ADP Single Crystals", *Phys. Stat. Solidi* **(a) 89** (1985) 1.

S.C. Sabharwal, T. Mirza, S.C. Karandikar and B. Ghosh, "Effect of Crucible Movement in B.S. Technique", *Crystal Res. and Technol.* **20** (1985) 837.

S.C. Sabharwal, S.P. Kathuria and B. Ghosh, "Thermoluminiscence in Gamma Irradiated NaI(Tl) Crystal", *J. Nucl. Tracks* **10** (1985) 107.

D.P. Gandhi, D.G. Desai and G.P. Kothiyal, "Antireflection Coatings for Intermediate IR", *VAC News* **15** (1985) 17.

S.C. Gadkari and S.C. Sabharwal, "A Circuit for Characterisation of Ferroelectrics", *BARC-1278* (1985).

Sangeeta, M.K. Rajpurkar and G.P. Kothiyal, "Growth and Characterisation of $LiNbO_3$ Crystals", *BARC-1280* (1985).

D. Sahoo and R.V. Srikantiah, "Preparation of HgCdTe : an IR Material", *BARC-1283* (1985).

G.P. Kothiyal, M.K. Rajpurkar and Ramprasad, "Measurement of Thermophysical Properties of Single Crystals of Germanium", Symp. on Crystal Growth, VECC, Calcutta, Jan.,1986.

S.C. Sabharwal and B. Ghosh, "Material Consideration for Growth of Scintillation Grade NaI(Tl) Crystals", *ibid.*

R.V. Srikantiah, H.J. Shetty and B. Ghosh, "Growth and Characteristics of HgI_2 Crystals", *ibid.*

S.C. Sabharwal, "Melt Growth of Crystals in Crucible", Invited Talk, *ibid*

S.C. Gadkari, T. Mirza, S.C. Karandikar and S.C. Sabharwal, "Growth and Characterisation of Undoped $Pb_5Ge_3O_{11}$", *ibid.*

Sangeeta, M.K. Rajpurkar, G.P. Kothiyal and B. Ghosh, "Growth of Single Crystals of $LiNbO_3$ and Measurement of its Curie Temperature", *ibid.*

M.S. Murthy, J.V. Satam, K.A. Sayed, B.N. Mahajan and M.L. Pandiyar, "A Triple Collector Mass Spectrometer for D/H Analysis of Water", 3rd National Symp. on Mass Spectrometry - Research, Applications and Instrumentation, Regional Research Laboratory, Hyderabad, Sept. 22-24, 1985.

V.V.K. Rama Rao, C.K. Nazare, A.R. Parker, M.K. Gor and K.A. Jadhav, "Development of a Quadrupole Mass Spectrometer", *ibid.*

M.S. Murthy, "Stable Isotopic Ratio Mass Spectrometers for Hydrogeology and Petroleum Exploration", International Conference on Petroleum Geochemistry and Exploration in the Afro-Asian Region, KDM Institute of Petroleum Exploration, Dehra Dun, Nov. 25-27, 1985.

M.S. Sayyed, "Development of Fabrication Technique for Xenon Flash Tube", Seminar on Recent Development in Scientific Glass Blowing, Kanpur, Dec. 1985.

M.S. Murthy and Yudhishter Lall, "Mass Spectrometer for Geochronology" *Nuclear India* **23** (1985) 9

M.K.V. Rao and V.K. Handu, "A Microprocessor Based Hot Cathode Ionization Gauge Controller", National Symposium on Instrumentation, Nagpur, Oct. 1985.

M. Thirumaleshwar, "Design, Fabrication & Performance of a Gifford-McMahon Cycle Cryorefrigerator Operating at 20K", Ph.D. Thesis I.I.Sc. Bangalore (1985).

M. Thirumaleshwar and S.V. Subramanyam, "Gifford-McMahon Cycle - a theoretical analysis", *Cryogenics* (UK) (Feb 1986).

M. Thirumaleshwar and S.V. Subramanyam, "Energy Analysis of a Gifford-McMahon Cycle Cryorefrigerator", *Cryogenics* (UK) (March 1986).

M. Thirumaleshwar and S.V. Subramanyam, "Heat Balance Analysis of Single Stage Gifford-McMahon Cycle Cryoregrigerator", *ibid.*

M. Thirumaleshwar and S.V. Subramanyam, "A Cryopump Operated by a Closed Cycle Helium Cryorefrigerator", Proc. Int. Conf. on Cryogenics, Calcutta, Dec. 10-13, 1985.

M. Thirumaleshwar, S.C. Joshi, R.C. Sharma, F.T. Carvalho, K.V. Madhusadan and A. Banerjee, "Development of a Small Air Liquifier", *ibid.*

S.C. Bapna and M. Thirumaleshwar, "Persistent Mode Operation of S.C. Magnet", *ibid.*

S.C. Bapna and M. Thirumaleshwar, "Characteristics of a S.C. Switch", Solid State Physics Symposium, Nagpur, Dec.,1985.

Jayalakshmi Santhanam, S.L. Verma and P. Vijendran, "Evaluation of a Glass Epoxy for Vacuum Applications", *Vacuum* **35** (*8*)(1985) 321-323

C.V.G. Nair, "Ultrahigh Vacuum Demountable Seals", *VAC News* **15** (1985)

B.D. Bhave and J.C. Monga, "Role of Special Matching in Optimisation of the Design of Low-light-level Imaging Systems", *Applied Optics* **24** (*14*) (1985) 2103-2108.

J.C. Monga and B.D. Bhave, "Optimisation Considerations on the Design of Active Night Viewing Systems", *Optics and Laser Technology* **17** (*9*) (1985) 201-204.

B.D. Bhave, J.C. Monga and P. Vijendran, "Spectral Corrections for the Design of Active and Passive Night Viewing Systems", Int. Symp. on Optoelectronic Imaging, New Delhi, Dec. 2-5, 1985.

Jayalakshmi Santhanam, "Investigations of Vacuum Properties of Kapton (R) a Polymide", National Symp. on Vac. Tech. & Applications to Chemical, Food and Pharmaceutical Industries, Calcutta, Nov. 1985.

Devaki Ramanathan, "Seal off and Processing Techniques for Field Emission Devices", *VAC News* **16** (*2*) (1985) 5-10; Proc. of National Symp. on Vac. Tech. & Sealed-Off Devices (Part 1).

J.S. Adhikari and M.K. Vijendra Rao, "A Microprocessor based Signal Averager for Waveform Recovery", *BARC-1292* (1985).

G. Singh, S.S. Ramamurthi and P.K. Iyengar, "A 450 Mev Electron Storage Ring for the Production of Synchrotron Radiation Source", Meeting on the Synchrotron Radiation in Developing Countries, Brazil, Nov. 1985.

P. Vijendran, "Role of Cryogenics in Vacuum", Invited Talk, National Symp. on Instrumentation, Nagpur University, Oct. 3-6, 1985.

P. Vijendran, "Relevance of Vacuum Technology in Analytical Instruments and Status in the Country", Invited Talk, Workshop cum Symposium on Analytical and Environmental Instrumentation, Jawaharlal Nehru University, Delhi, Dec. 26-28, 1985.

P. Vijendran, "Impact of Chemistry on Vacuum Technology", Invited Talk, National Symp. on Vacuum Technology and Applications to Chemical, Food, Drug & Pharmaceutical Industries, Calcutta, Nov-28-30, 1985.

Subimal Saha, B. Banerjee and S.S. Ramamurthy, "96KVA Water Cooled Resin Cast High Voltage Transformer", Int. Conf. on Transformers,

Trafotech- 86, Bombay, Feb. 20-21, 1986.

Subimal Saha, P.K. Banerjee and S.S. Ramamurthy, "High Frequency (20 KHz) High Voltage Ferrite Core Transformer", *ibid.*

A.V. Thakur and T.K. Saha, "Some typical applications of E.B.W.", Proc. Symp. on Recent Developments in Welding Metallurgy and Processes, Bombay, 1985.

A.V. Thakur, T.Vijayan and T.K. Saha, "Welding of dissimilar metals with electron-beam welding technique", *ibid.*

P. Satyamurthy, N. Venkatramani and V.K. Rohatgi, "Analysis of heat fluxes in the electrode walls of a combustion driven MHD generator", *Energy Conversion and Management* **25(1)** (1985) 195-198.

G.P. Gupta, V.K. Rohatgi, G. Paran Gowda and M.L. Mittal, "Radiation energy loss and the electrical conductivity in non-equilibrium MHD generator", *J. Propulsion and Power* **1** (1985) 161.

P.R. Dastidar, V.K. Rohatgi, S.N. Seshadri, S. Sridharan, V.R. Malghan and V. Balasubramaniam, "Indian MHD program - Status Review", 23rd Symp. on Engineering Aspects of MHD, Pittsburgh, USA, 1985

A.K. Das, O.K. Subramaniam and V.K. Rohtgi, "Evaluation of fuel options for Indian commercial MHD plant", *ibid.*

G.P. Gupta, V.K. Rohatgi, G.P. Gowde and M.L. Mittal, "Radiation and ionizational non-equilibrium effects on the electron density in a non-equilibrium MHD generator duct", *Energy Conversion and Management* **25** (1985) 115

M.I. James, M.L. Mittal, G.P. Gupta and V.K. Rohatgi, "Electric potential behaviour in segmented Faraday-type MHD generators", *ibid.*, 211

G.P. Gupta, "Electrode phenomena and performance of combustion MHD generators", Proc. 3rd National Symp. on Science & Technology of Plasmas, Jaipur, 1985 (invited talk)

G.P. Gupta, M.L. Mittal and V.K. Rohatgi, "Effect of radioactive power loss on the electrical conductivity in non-equilibrium MHD generators", *ibid.*

V.K. Rohatgi, "A look at the fusion reactor technology", *B.A.R.C.-1284* (1985)

"Scientific Report on the first experimental run of the ZINC Channel at the Indian MHD facility", Trichy, March 25-28, 1985

"Technical report on the first power run of the Indian MHD pilot plant", August 13-16, 1985.

P.P. Vaidya, K.R. Gopalakrishnan, V.A. Pethe and T. Anjaneyulu, "A New Method for DAC Corrections for Application in Nuclear ADC", *Nuclear Instruments and Methods in Physics Research A* **240** (1985) 357-361.

P.P. Vaidya, K.R. Gopalakrishnan, V.A. Pethe and T. Anjaneyulu, "A New Method for High Speed Nuclear ADC's Using Commercially Available ADC's and DAC's", *ibid.* **A 241** (1985) 218-220.

G. Haridasan, "Advances in Biomedical Instrumentation", Proc. XI All India Symposium-cum-Workshop on Biomedical Engineering, Bombay, Dec., 15-18, 1985.

J.P. Babu and G.D. Jindal, "Clinical Applications of Bipolar Impedance Plethysmography", *ibid.*

J.P. Babu, A. Balasubramanian and G.D. Jindal, "Microprocessor Based Impedance Cardiography", *ibid.*

G. Haridasan, "Electrical Activity in Skeletal Muscles under Conditions of Isometric Contractions, with Needle Electrode", *ibid.*

V.M. Joshi, "The Role of Digital Scan Converter in Ultrasonic Imaging", *ibid.*

P.L. Hegisthe, M. Sajid, V.M. Joshi and G. Haridasan, "Development of Static/Dynamic Ultrasonic Imaging System", *ibid.*

Ram Singh, "Problems of Maintenance and Servicing of Hospital Equipments", *ibid.*

G. Haridasan, "Development of Medical Instrumentation Analysis of Indian Situation vis-a-vis World Scenario", *ibid.*

G.D. Jindal and J.P. Babu, "Calibration of dz/dt in Impedance Plethysmography", *Medical & Biological Engineering & Computing* (UK) **23,** (1985).

S.D. Dewoolkar, G.D. Jindal, M.D. Kelkar, Sadhana Suraokar, J.P. Babu and G.B. Parulkar, "Assessment of Distal Arterial Runoff Using Impedance Plethysmography", Proc. Int. Congress of Angiology, Athens, June 1985.

Sadhana B. Suraokar, G.D. Jindal, M.D. Kelkar, S.D. Dewoolkar, J.P. Babu and G.B. Parulkar, "Noninvasive Diagnosis of Deep Vein Thrombois using on Line Impedance Plethysmography", *ibid.*

G.D. Jindal, Sadhana Suraokar, J.P. Babu, M.D. Kelkar and G.B. Parulkar, "On-line Impedance Plethysmography for the Study of Blood Circulation", *ibid.*

G.D. Jindal, J.P. Babu, Sadhana Suroakar, M.D. Kelkar, J.B. Dharani and G.B. Parulkar, "Assessment of Pulmonary Hypertension in Patients with Mitral Stenois Using Vector Impedance Cardiography", *ibid.*

G.D. Jindal, "Impedance Plethysmography for Screening Vascular Disorders", *J. Post Graduate Medicine* **32** (1986).

10. TECHNICAL SERVICES

10·1 Civil Engineering

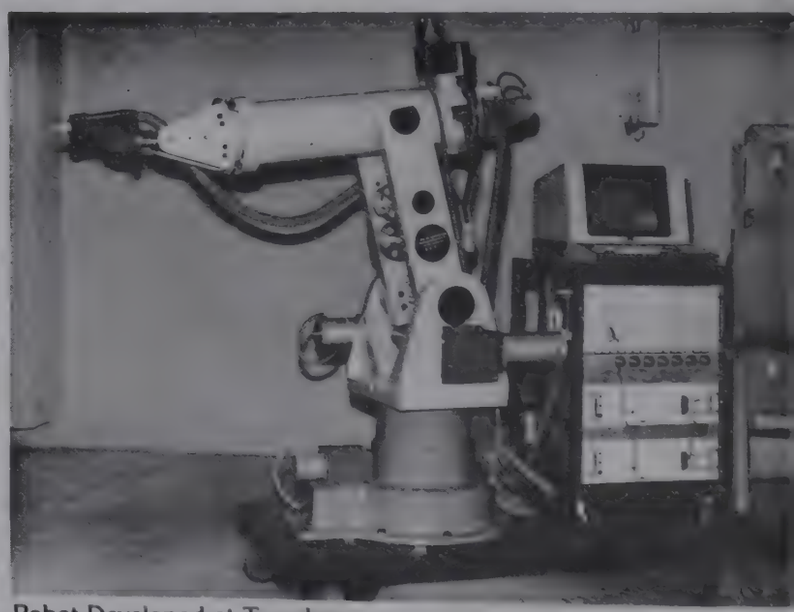
The Civil Engineering Group of BARC is responsible for design and construction of all works related to BARC activities at Trombay, Vashi (New Bombay), Tarapur, Srinagar and Gauribidanur. During this year construction and maintenance work totalling to Rs. 9·12 crores were carried out. This included completion of two engineering laboratories and an office building. Several projects at Trombay are at various stages of implementation. At Vashi, Labelled Compounds Laboratory is nearing completion and work on administrative and common service facilities has been started. At Tarapur construction of Solid Storage Surveillance Facility (S3F) costing Rs. 6·36 crores has been completed. Other plant works and residential quarters costing Rs. 2·44 crores have also been completed at Tarapur. Construction of additional residential quarters at Tarapur at a cost of Rs. 109·00 lakhs and Waste Disposal Facility and physical protection measures costing Rs. 92·00 lakhs is at various stages of progress. At Srinagar, civil engineering works for extension of workshop, stores, computer facility and residential quarters at a total cost of Rs. 53·00 lakhs have been completed. The Architectural Section of Civil Engineering Group continued to render architectural services not only to all the projects undertaken by BARC, but also to other units of DAE and to some of the outside agencies like the Department of Electronics and the Department of Science and Technology.

10·2 Electrical & Mechanical Services

Operation and maintenance of all the electrical installations, pneumatic, hydraulic and vacuum systems, cranes and airconditioning equipment was carried out. Electrical and mechanical services for six projects at Trombay, Tarapur and Srinagar was completed.

10.3 Central Workshops

Central Workshops of BARC continued the work on design, development and fabrication of special components and equipment required for the various units of DAE. The total cost of the components and equipment made during this year would be about Rs. 5 crores. Some of the important jobs carried out by CWS are the following : design and development of six axes multipurpose robot of 50 kg capacity; design and fabrication of a Triple Axis Neutron Spectrometer with rotating monochrometer drum which provides shielding at all angular positions with the help of moving wedges; design and fabrication of a vertical honing machine which can be used for honing of large size components of power reactor fuelling machine head; a spent fuel chopper assembly consisting of fuel feed system, shear system, distributor system and associated drives, and high pressure high capacity hydraulic cylinders for use in power reactor fuel reprocessing plants. Some of the important jobs which are nearing completion are the design and fabrication of work handling unit for electron beam welding machines, manufacture of fuelling machine heads, end-fittings and linear tubes for the KAPP, neutron radiography rig for IGCAR, Kalpakkam, ionisation and scattering chamber for MEHIA Project. Development of different types of spectrometers for basic research is in progress.



Robot Developed at Trombay

Remote Handling & Robotics

Robotics and remote handling devices play an important role in handling radioactive materials and

components. In order to minimise exposure of operators to radiation, a variety of servo manipulators, remote viewing TV systems and automatic handling devices are being developed. A prototype five-axis articulated robot was designed, manufactured and tested. This type of robot will be useful in low activity hot cells and glove boxes employed in the production of plutonium and uranium-233 contained fuel. Work has been intitiated on the development of a completely indigenous mobile robot which could move around under radio control and perform operations required in reactor maintenance, decontamination and decommissioning of nuclear facilities.

10·4 Computer Centre

The network of Norsk Data super mini computers with a large number of terminals distributed in the various laboratories continued to provide the basic computational support to the scientists and engineers in BARC. Besides prime usage for scientific computing, these machines are also being extensively used for applications in the field of computer graphics, database management and information processing. Several new features have been added to the ND operating system, such as facility for deferred spooling, command modifications, users dialogue facility, implementation of NAG library V·11 on ND systems, and Fortran library modification using array processor.

10·5 Technical Information

BARC Library has now nearly 730,000 documents including about 76,000 books, 54,000 bound volumes of periodicals, 19,300 patents and standards and more than 580,000 technical reports. More than 1,800 scientific and technical journals are received in the Library, the majority of which are received on subscription and the remaining ones either on exchange basis or free of cost. During this year some of the activities of the Library were computerised making use of the PRIME-450 computer installed in the Library & Information Services premises. Necessary software was developed on the ND 570 computer at the BARC Computer Centre so that the INIS output tape received from IAEA could be processed at Trombay for dissemination of bibliographic information on selected topics which are of interest to individual BARC scientists. Work on creating a database related to the catalogue of books in the BARC Library is progressing. Books circulation has already been computerised. India's participation in the International Nuclear Information System (INIS) at Vienna was continued. During this year about 600 technical and scientific titles published in India were added to the INIS database.

During this year about 100 technical publications were brought out, of which 90 were technical reports and rest were proceedings of symposia and seminars.

10·6 Translation

Translations were done from French, German, Italian, Japanese and Russian languages at the request of scientists and engineers of BARC and other constituent units of DAE. Copies of the translations were deposited in the National Science Library, New Delhi for the National Data Bank of Translations. Interpretation service in foreign languages was also provided on many occasions.

10·7 Landscaping

Landscaping was done on about 39,000 m^2 area in Trombay, Anushaktinagar and Tarapur. Rejuvenation of about 3,800 m^2 garden in Trombay was also carried out. About 350,000 saplings of various types were planted and about 150 kg seeds of different types of trees were sown on Trombay Hills for afforestation purposes. About 2,4000 trees were planted at the Centre for Advanced Technology, Indore.

10·8 Contributory Health Service

The scheme at present covers 62,600 beneficiaries. BARC Hospital and zonal dispensaries continued to extend diagnostic and therapeutic facilities to the beneficiaries. At present the BARC Hospital has 160 beds.

Active family welfare programme was continued. The Social Service Section continued to render

assistance to the beneficiaries and more than 14,500 cases were given counselling. The Trombay Dispensary continued its Occupational Health Activities and the Accident Prevention Programme.

An intensive cardiac care unit with 8 beds was commissioned in the BARC Hospital on 24th June, 1985. This unit has equipment for monitoring by telemetry, resuscitation, and pacing. Supportive investigative facilities such as Stress Test and 2 DE are being fuly utilized.

10·9 Radiation Medicine Service

Radiation Medicine Centre continued to provide clinical nuclear medicine facilities to all cases referred to it from many parts of India. A number of investigations like scintigraphic imaging of thyroid, brain, bone, kidney, heart, gall bladder, lungs, liver, etc. are performed every day. A large number of in vitro radioimmunoassay (RIA) are also done. Altogether approximately 22,000 investigations were done during this year. This year there was considerable increase in the number of nuclear cardiology studies like myocardial imaging and ejection fraction studies. The ultrasonic scanner played an important role in the complementary assessment of thyroid diseases, liver, kidney, pelvic and abdominal masses. The usefulness of this method in pediatric cerebral abnormalities is undoubtedly one of the major investigative measures in children. Radioiodine therapy for thyroid cancer and hyper- thyroidism was carried out. During this year 5,700 patients came for follow up in the thyroid clinic.

Publications

S. Challappa, G.R. Kamat and R.N. Arya, "Diffusion Bonding - An Alternative Method of Manufacturing Seal-discs".

S. Challappa and G.R. Kamat, "Development of Nuclear grade castings at Central Workshops".

S. Challappa, B.R. Bairi, K. Rangaswami and S. Guha, "Development of Six - Axis Articulated Welding Robot".

G.R. Kamat, "Pitting and its control during Electroplating of Stainless Steel".

S. Challappa and M. Jayendranath, "Experience in the manufacture of power reactor components in CWS & the strategy for the future projects".

S. Challappa, M.G. Shrinivasan, A. Jasbir Singh and A. Manjunatha, "Quality Assurance Concept on Fuelling Machine Head Components and Assembly in Central Workshops".

S. Challappa, M. Jayendranath and A. Mohan Rao, "Experience in the Manufacture of Fuelling Machine Heads in Central Workshops".

M.G. Shrinivasan, A. Jasbir Singh and P.P. Chandrachoodan, "Applications of Quality Control and Inspection Techniques on Critical Components".

S. Challappa and S. Guha, "Robotics and its terminology".

M. Sundaram and R.N. Sachdev, "Infra-red Instruments Measurement of CO and Hydrocarbon in Automobile Exhaust".

11. TECHNOLOGY TRANSFER

The Bhabha Atomic Research Centre is a task oriented research centre with the primary objective of providing back-up to the Indian nuclear programme and production and utilisation of radioisotopes and radiation. As primary inputs to the nuclear programme, technologies like electronics and materials were developed. Because of the exigencies of sophistication and time schedules, the productionisation also had to be undertaken by the Department of Atomic Energy by setting up units like ECIL and NFC. This facilitated efficient transfer of knowledge. The range of products varied from relatively simple devices like GM counters to control systems for reactors in electronics and special materials like zirconium and niobium to nuclear fuel materials like uranium oxide. In the context of continuous updating of these technologies, the wide R & D base at BARC has provided the necessary back-up to these production activities. In addition, it has also made it possible to extend it in the direction of newer technologies like fast breeder reactors, special fuel and other materials required for them and the engineering back-up. Monitoring of the quality and efficiency of technology generation and delivery is inlaid in the system by movement of personnel between R & D and production units and a very close interaction between them.

However, BARC's activities interface with many areas, a few examples of which are the following :

Industry

There has been a very close interaction with engineering and fabrication industry for some of the crucial components like fuelling machines, large calandrias, heat exchangers, etc. This has led to a strong capability in the Indian Industry for undertaking fabrication of very sophisticated jobs with extremely rigid specification. While this is not technology transfer in the conventional sense, it may be difficult to find a better example of quality technology generation and delivery to the Industry.

Another successful method of technology transfer which was adopted by BARC is demonstrated in the case of BARC–IBP collaboration. Vacuum Technology which was again a vital input to the nuclear programme was developed and transferred to IBP. This was done along with knowhow and personnel. Then the process of weaning was initiated in this strong interaction and today IBP is in a position to be on its own, with its own expertise and ability to meet many of the sophisticated requirements for large systems in the country. BARC is no more obliged to support it by showing preference for its products. However, there are some high technology products which BARC has had to undertake at production level. Beryllium, for instance, is required in the Indian space programme and by electronics industry as Be-Cu alloy. This technology was developed and the production plant has also had to be set up by BARC. Similarly superconducting materials and wire drawing technology have been developed and this will have to be undertaken at BARC. The expertise in extractive metallurgy has been used for developing a flowsheet and setting up a 2 tonne/year tin production plant at Raipur. This technology is being transferred to the Madhya Pradesh Government but a continuing collaboration would be required.

Many of the industrial activities like use of radiotracers in hydrology and desilting operations, radioisotopes for radiography, level gauging in large tanks etc. cannot, at the present stage, be transferred in the conventional sense. Hence BARC has to take these up along with an extensive effort for user education.

Since a very wide R & D base has had to be developed for meeting the primary objectives, an effort has, in the last couple of years, been made to reorient/modify processes and instruments worked upon for the nuclear power programme and make them useful for industry. Over 200 of such items have been listed in two volumes of booklets which have been widely circulated to industrial organisations, State Industrial Development Corporations, Industrial Associations, etc. free of cost. In the last couple of years, 13 technologies have been transferred, 17 technologies are ready for transfer and 35 technologies are under various stages of evaluation. All these items are a step ahead of the technologies being presently used by the Industry and a special effort is made to help the industry to overcome any initial

problems in manufacturing by an uninhibited interaction with scientists directly involved in the development of the instrument/technology.

Agriculture

Mutation breeding has been researched at BARC for over a decade now and 49 varieties of pulses/grains etc. have been identified with superior properties. Six of these have already undergone the various steps involved in field trials and upgrading the scale of testing and have been released by the Seed Corporation for commercial use. Several others are at various stages of testing. This is a fine example of high quality agricultural research delivering direct commercial benefit to the country. In addition to other qualities like disease resistance etc. these varieties have a 15 to 20% higher yield. Considering the present prices and the fact that 15,000 hectares are already under cultivation of these varieties, the financial benefit is now in terms of crores of rupees. The seed multiplication for distribution every year is very substantial and hence these gains will increase rapidly.

Health

In this field, while developments like bilirubin strips for early detection of jaundice will facilitate medical work, specially in rural areas where trained manpower is scarce, technologies developed in BARC are such that they are not presently amenable to conventional transfer to the industry.

The sterilisation of medical products is a very apt example. As the industry is not able to take up sterilisation plants yet BARC has set it up for the users. Similarly production of radio-pharmaceuticals has been taken up by BARC but the health sector utilises them. Use of radiations and radioisotopes developed at BARC is being put to practice by the Radiation Medicine Centre. BARC supplies 50,000 consignments of different isotopes to 1400 institutions. Radiopharmaceuticals are being produced for use by over 500,000 patients. The impact of these technlogies on the health sector are very far reaching.

12. HUMAN RESOURCES DEVELOPMENT

One hundred and ninety scientists and engineers who successfully completed the 28th course of Training School were absorbed in August, 1985 in various units of DAE. Currently 243 scientists and engineers are undergoing training in the 29th course. The training programme was suitably modified so that the requirements of units like CAT, Indore, envisaged expansion of Power Projects and Heavy Water Projects also could be met. Steps have been initiated to train candidates specifically for O & M of fast reactors, and in subjects like Accelerator Physics, Fusion Physics, Microprocessor System Development, Robotics, etc. Short term courses on "Microprocessors" and "Computers" were run for the BARC personnel.

At the request of IAEA, an inter-regional training course on radiation protection was conducted at Trombay during December 1984 to May 1985 in which 12 trainees from foreign countries participated.

Training courses were counducted to meet the man-power requirement of medical physicists and radiological safety officers. Short-term courses were also conducted on safety aspects associated with industrial radiography, erection and maintenance of nucleonic gauges, research applications of radioisotopes, etc.

Two training courses in RIA techniques were offered to medical and paramedical personnel from the leading hospitals in the country. Scientists from Isotope Group participated in the training course conducted by the IAEA for RIA and hospital pharmacy.

Under the Faculty Improvement Programme of the UGC three lecturers are carrying out research in BARC. Under varous schemes, 4 scientists from Syria, 3 scientists from the Philippines and one each from Bangladesh, Vietnam and Iran were trained in BARC.

13. GENERAL

About 7,000 persons including Heads of States, Ministers, Parliamentarians, Diplomats, Defence Personnel and Visiting Scientists visited BARC. On an average, one Trombay Colloquium was held every month.

About 100 scheduled castes and scheduled tribes candidates were recruited to various posts in BARC. During this year 35 staff members passed Hindi examination and 17 staff members appeared for Hindi typing examination. A Hindi Workshop was organised for senior administrative officers and a seminar on future directions of Indian Science was organised in Hindi in which a number of eminent national scientists participated.

The Benevelent Fund set up in 1963 has now more than 3,000 members and disbursed about Rs. 30,000 during this year. Besides, a Family Relief Scheme is also in force by which all the members make a one-time contribution towards financial assistance to the family of any member who dies.

14. CENTRE FOR ADVANCED TECHNOLOGY, INDORE

Work on setting up the Centre for Advanced Technology is in the first phase. Effort is concentrated on accelerator and laser development programmes. A few scientific officers and technical staff have moved to Indore to carry out development programmes. A laboratory space of about 3,225 m^2 has been kept ready during this year. Two workshops of 3,720 m^2 area are under construction. A housing complex of 90 tenements are ready for occupation.

The design details of a weak focussing 450 MeV Synchrotron Radiation Source was completed using the facilities at BARC. Fabrication drawings of some of the major components such as dipoles, radiofrequency cavities and vacuum chamber are under preparation. This Synchrotron Radiation Source (SRS) will have the critical wave length of 61 A at 100 mA current and will give a flux of $4{\cdot}8 \times 10^{13}$ photon per second per milli radian in the band width of 0·5%. The life time will be of several hours. This machine is expected to be powerful vacuum ultra violet source for spectroscopy studies and for carrying out work in the fields of photo disorption and photo dissociation.

The two laser programmes to be undertaken at CAT initially are development of copper vapour laser (CVL) and development of transverse flow high power carbon dioxide (CO_2) laser. Some work in these areas has been already initiated at BARC. A 10 watt CVL has been developed. The laser operates at 5 kHz and gives a peak power of 100 kWt in 20 nsec pulses. Basic design of the CO_2 laser has been completed. The laser will be modular in construction with each module of 2 kW power.

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